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Space Station Science Payload Integration Management Study

FINAL REPORT

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SPACE STATION SCIENCE PAYLOAD INTEGRATION MANAGEMENT STUDY

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APPROVED BY: William E. McAllum

W. E. McAllum, NASA Task Manager

CONCURRENCE: W D Womack

W. D. Womack, NASA Technical Manager

CONCURRENCE: Wayne A. Eaton

W. A. Eaton, Chief, Project Mission Office

SPACE STATION SCIENCE PAYLOAD INTEGRATION MANAGEMENT STUDY

Team Members

JSC TASK MANAGER:	W.E. McAllum
RCA TASK MANAGER:	Bernestine Dickey
RCA TEAM MEMBERS:	Kimberly Goerig Judy Hartsfield Patricia Johnson Gail Marlatt Kelly Putzan Gloria Salinas Jim Searcy Joyce Schultz Britt Walters

Space Station Science Integration
Management Study

Table of Contents

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

ACRONYMS/ABBREVIATIONS

AO - Announcement of Opportunity

C/O - Checkout

CUP - Consolidated Utilization Plan

DFA - Data Flow Analyst

DOC - Discipline Operations Center

DoD - Department of Defense

DOR - Discipline Operations Representative

DWG - Discipline Working Group

ESA - European Space Agency

ESC - Element Support Center

EVA - Extravehicular Activity

EXP - Experiment

GSFC - Goddard Space Flight Center

ICD - Interface Control Documents

I/F - Interface

Integ - Integration

ISSUB - International Space Station Users Board

JEM - Japanese Experiment Module

JSC - Johnson Space Center

KSC - Kennedy Space Center

LeRC - Lewis Research Center

Log - Logistic

MCB - Multilateral Control Board

MOU - Memorandum of Understanding

MSFC - Marshall Space Flight Center

NASA - National Aeronautics and Space Administration

OSSA - Office of Space Science and Applications

PAM - Payload Accommodations Manager

PI - Principle Investigator

PIA - Payload Interface Adapter

PIP - Payload Integration Plan

PITF - Payload Integration Training Facility

PMC - Permanent Manned Capability

POCC - Payload Operations Control Center

POIC - Payload Operations Integration Center

PTIF - Payload Training Integration Facility

ROC - Regional Operations Centers

S&T - Science and Technology

SS - Space Station

SSOTF - Space Station Operations Task Force

SSPF - Space Station Processing Facility

SSSOMC - Space Station Science Operations Management Concept

SSUB - Space Station Users Board

SSUWG - Space Science User Working Group

SUB DIS - Subdiscipline

U.S. - United States

UIF - User Integration Facility

UIO - User Integration Office

UOF - User Operations Facilities

USER - United Space Experimental Researchers

Executive Summary

SPACE STATION SCIENCE PAYLOAD INTEGRATION MANAGEMENT STUDY

EXECUTIVE SUMMARY

INTRODUCTION

The Space Station Science Payload Integration Management [redacted] to provide the Office of Space Science and Applications (OSSA) with a concept and recommendation for managing the major integration activities in OSSA [redacted] fields during the Space Station era beginning with P[redacted]C) through mature operations. It is anticipated that OSSA will manage and provide the majority of the United States user Science Payloads that are conducted on the Space Station. The study concentrated on:

1. Re-evaulating the current approach and organization for accomplishing payload integration activities for Shuttle/Spacelab missions for applicability to Space Station operations.

2. Defining an integration management approach that accommodates the differences and/or unique characteristics of Space Station operations that will ensure maximum science return to the user community for participating in the Space Station Program.

This study effort utilized, where applicable, recommendations from the Space Station Operations Task Force (SSOTF) Study Report and the Space Station Science Operations Management Concepts (SSSOMC). However, it should be emphasized that concepts developed for evaluation and consideration by this study team were developed independently of the SSOTF and SSSOMC recommendations because data from those studies were not available when this study effort was initiated. As results of these studies became available, recommendations were incorporated where applicable.

The term integration, as used in this study, includes all the necessary functions, activities and elements of a payload that must be combined, verified, and certified to ensure that it can be launched, implemented and returned to earth successfully. These include:

A. Science Planning and Resource Allocation Management

B. Payload Integration Management for Physical and Analytical Integration Activity

C. Operations Management which includes real-time mission support and training

This study effort emphasized development of an optimum integration management concept to best manage and implement these integration activities.

STUDY APPROACH

The basic approach taken to develop an optimum Integration Management concept for OSSA consisted of:

1. Identifying the major integration activities involved in designing and developing a complement of scientific payloads from start to finish.

2. Defining how these integration functions are presently being managed by OSSA for Shuttle/Spacelab Missions.

3. Assessing the applicability of the current management approach in light of the differences between Shuttle operations and Space Station operations.

4. Identifying various concepts for managing user science integration, resource allocation, hardware integration and operations management activities, taking into account the unique characteristics of Space Station that will affect user payload development and integration activities.

5. Evaluating concepts against selection criteria using pros and cons to determine an optimum concept for accommodating OSSA payloads.

6. Using results from SSOTF and SSSOMC where applicable to further develop study concepts and rationale.

STUDY OBJECTIVES

The overall objective of the study is to define an optimum User Integration Management Structure that will provide OSSA Users with an effective management structure for program planning and policy decision-making; a method for implementing program goals, guidelines and objectives within available resources; and an effective interface with the Space Station Program Organization to ensure:

1. Coordination, integration, and accommodation of OSSA user science requirements in the overall Space Station program.

2. Promotion of a single point advocacy between the OSSA user community and Space Station Program organization during all phases of payload accommodations, interface, integration and operations.

3. Maximum science and technology return to OSSA Payload users.

4. Maximum on-orbit resource utilization for experiment operations while minimizing on-orbit hardware repair and maintenance.

5. Equitable trade-off between ground preparations training and operations with on-orbit crew utilization for these activities.

6. Minimum cost to users for payload development activities and operations by developing and maintaining standard interfaces for hardware/rack and stowage items, by promoting modularity and by developing and cross utilizing generic laboratory equipment among OSSA science discipline users.

7. Coordination of replanning activities for on-orbit operations in real-time to ensure optimum use of allocated resources.

STUDY OVERVIEW

Six concepts were developed initially by the study team to describe a management concept for accomplishing science integration, resource allocation, hardware integration and operations activities. All concepts are based on the management level where integration facilities for hardware integration, training, real-time operations support and inflight activities are managed and controlled to verify payload compatibility prior to final interface checkouts with Space Station.

The concepts ranged from having all integration activities being managed by a Multinational Users Board where all user requirements are integrated and verified prior to interfacing with Space Station to a Distributed Integration Management Concept where planning and implementation activities are distributed at various levels within the NASA Management hierachy.

The six concepts evaluated are as follows:

1. The Multinational Payload Integration Management Facility concept focuses on a centralized user integration facility where all Station user (domestic and foreign) payload integration activities are managed and performed prior to Space Station interface checkout. It also assumes that an Integration Organization managed by an international organization would perform these activities for all Station users.

2. The Centralized U.S. User Integration Management Facility Concept focuses on a centralized United States User facility managed by a designated NASA Headquarters Office where all U.S. user payload integration activities are managed and conducted prior to Space Station interface checkout. Total payload compatibility assessments and integration activities for all users (including international partners) would be performed by Space Station.

3. The OSSA User Integration Management Facility Concept focuses on a centralized user integration facility and organization for conducting OSSA payload integration activities, relying on the Space Station to manage and implement overall user payload integration activities.

4. The Discipline User Support to Space Station Integration Concept focuses on having all integration activities for OSSA Payload Users managed and implemented at science discipline facilities and offices which rely on Space Station to provide overall user payload integration management.

5. The Project level support to the Space Station Concept focuses on all integration functions being implemented at designated subdiscipline (project) facilities at

designated NASA field centers which rely on Space Station for user payload planning, management and control.

6. The Distributed Integration Facility Concept focuses on distributing integration functions and responsibilites among all levels of management with final OSSA user integration activities being performed at an integration center managed and controlled by OSSA at NASA Headquarters.

The major differences between the concepts are the management levels within NASA's organizational structure where Integration Facilities are managed and controlled. A preliminary analysis of each concept revealed pros and cons for each concept that suggested that a combination of these concepts is required depending on the integration functions that must be performed. The different aspects of management control and implementation for resource allocation and management, science integration and management, hardware integration (physical and analytical), payload compatibility assessments system analysis, and in-flight operations management require different levels of management and control for maximum efficiency.

STUDY CONCLUSIONS/RECOMMENDATIONS

The study team recommends that the OSSA Space Station integr[redacted] Concept depicted in Figure I-1 [redacted] be used and develop[redacted] user accommodations in three major areas:

1. Science Planning and Resource Allocations/Management

2. OSSA User payload integration management to include ground integration and checkout management for physical and analytical hardware integration activities, ground support, payload compatibility assessments and system analysis.

3. Real-time operations management to include integrated training activities for flight and ground crew, on-orbit replanning activities and data management.

The concept emphasizes that science planning and resource allocation should be managed by OSSA Science Discipline Organization with resource management, payload integration, and operations being managed by OSSA SS User Integration Office (UIO).

Figure i-2 highlights the suggested management approach for science planning and resource allocation and management. This approach allows the United Space Experimental Researchers (USER) community to manage and control its resources, provide effective science definition and coordination for the user community and provide an effective interface with the Space Station program.

Science requirements are developed and provided by OSSA science discipline divisions (Life Sciences, Materials Sciences, etc.) and are used for supporting Space Station 5 year strategic utilization planning and 2 year tactical planning activities. These plans are the basis for determining Space Station resource allocations and flight increment planning activities. Once resources are allocated to OSSA and distributed to Science

OSSA SPACE STATION INTEGRATION MANAGEMENT CONCEPT

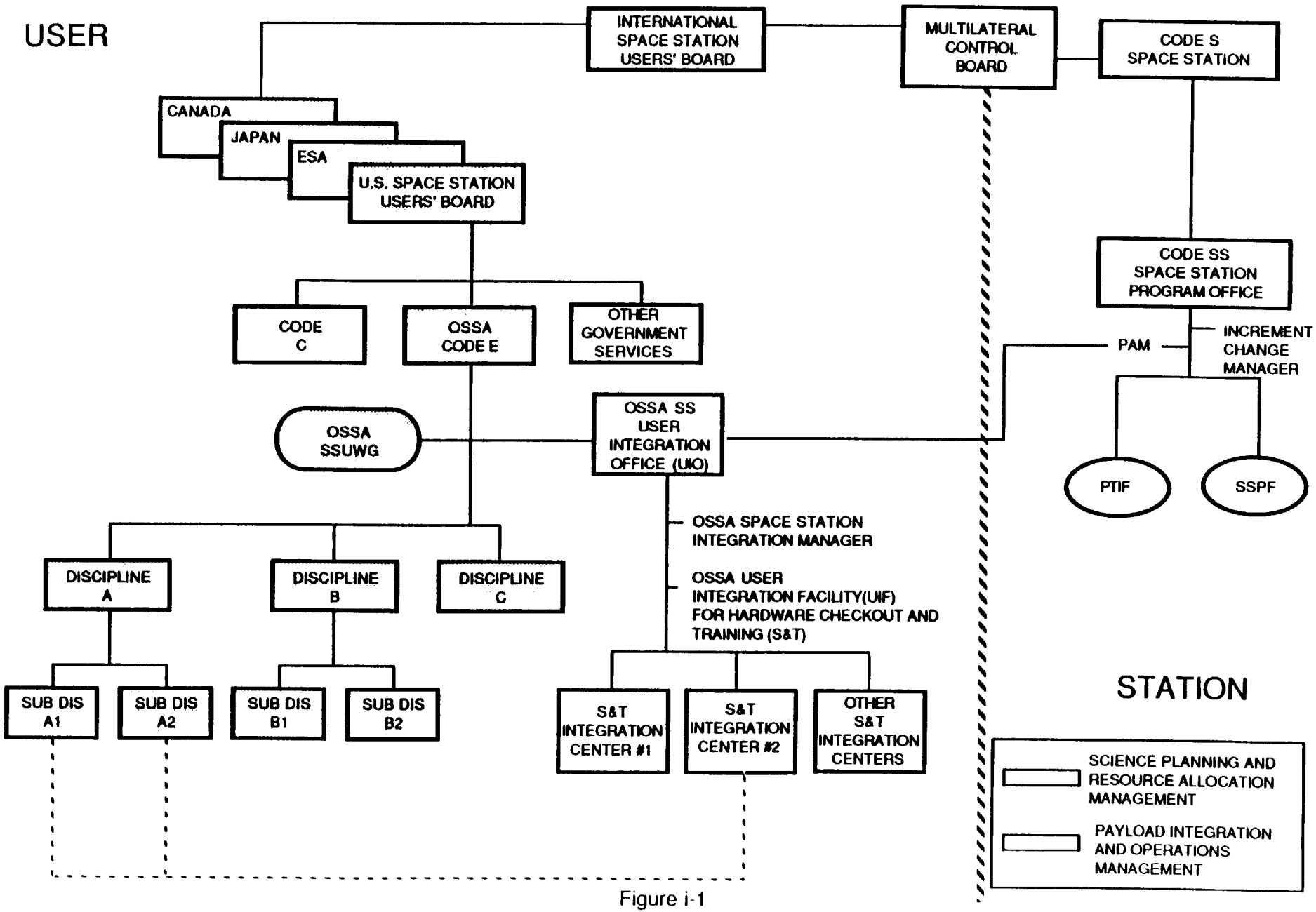


Figure i-1

OSSA SPACE STATION USER SCIENCE PLANNING AND RESOURCE ALLOCATION MANAGEMENT APPROACH

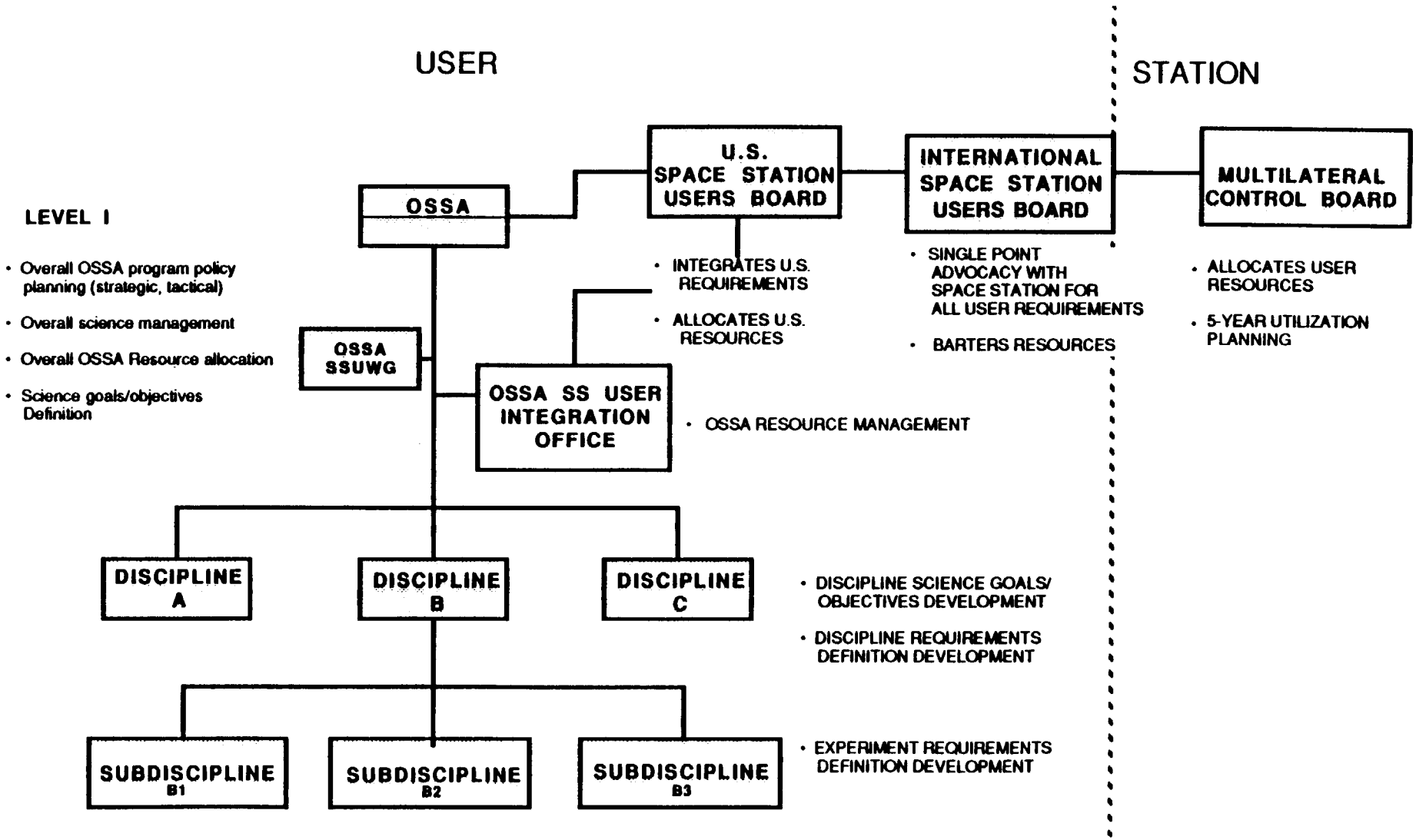


Figure i-2

Discipline Offices, these allocations are managed and configuration controls maintained by OSSA's Space Station User Integration Office.

Figure i-3 emphasizes the suggested management approach for OSSA payload integration activities and real-time operations management. This approach focuses on an OSSA User Integration Office (UIO) at NASA Headquarters that manages an OSSA User Integration Facility (UIF) where all OSSA science payloads are certified and verified prior to final interface checkout at the launch site. This facility should be a certified S & T center for payload experiment (rack-to-rack), and rack-to-module integration activities. This certification process will also include OSSA Payload integrated training activities and operations management support during real-time operations.

Rack level hardware integration activities and discipline level training activities are implemented at Science and Technology (S&T) Integration Centers at designated NASA field centers. Figure i-4 highlights the hardware Integration flow.

The SSOTF recommends that a Payload Operations Integration Center (POIC) managed and controlled by Space Station should be given responsibility for inflight operations management for the USER community with support from USER Discipline Operations Centers (DOCS), Regional Operations Centers (ROCs), and User Operations Facilities (UOF). Reference Figure i-5. The SSOTF recommended that the POIC should be Station-managed because of the complexity of both Space Station Systems and USER operations and to ensure Station safety. This is different from current Shuttle Operations in that user Operations in the Payload Operations Control Center (POCC) are managed and controlled by the user community. It is recommended that the USER community should be an integrated part of the POIC management and control loop as members of the POIC Cadre Support Team. The study team feels that User Operations and requirements are best served if the POIC includes a cadre of operations and support personnel from the USER community colocated with POIC cadre support personnel in the POIC Management Control and Support Rooms and participate in all real-time operations decisions that affect user payloads. Figure i-6 defines the recommended role for the USER community within the POIC.

To support OSSA payload integration and operations activities, as recommended by this concept the following facilities or equivalent are required:

1. S&T Centers to support experiment development and rack integration activites.

2. Discipline Operations Centers to support experiment and discipline training activities and operations coordination and management of PIs during real-time operations.

3. USER Integrated Facility to support hardware integration activities for experiment compatibility and rack-to-module or PIA interface; OSSA integrated science verification activities; integrated training for flight and ground personnel; and on-orbit replanning activities for OSSA payloads.

In summary, the concept recommended by the study team provides for:

OSSA SPACE STATION INTEGRATION MANAGEMENT CONCEPT
GROUND INTEGRATION AND CHECKOUT MANAGEMENT

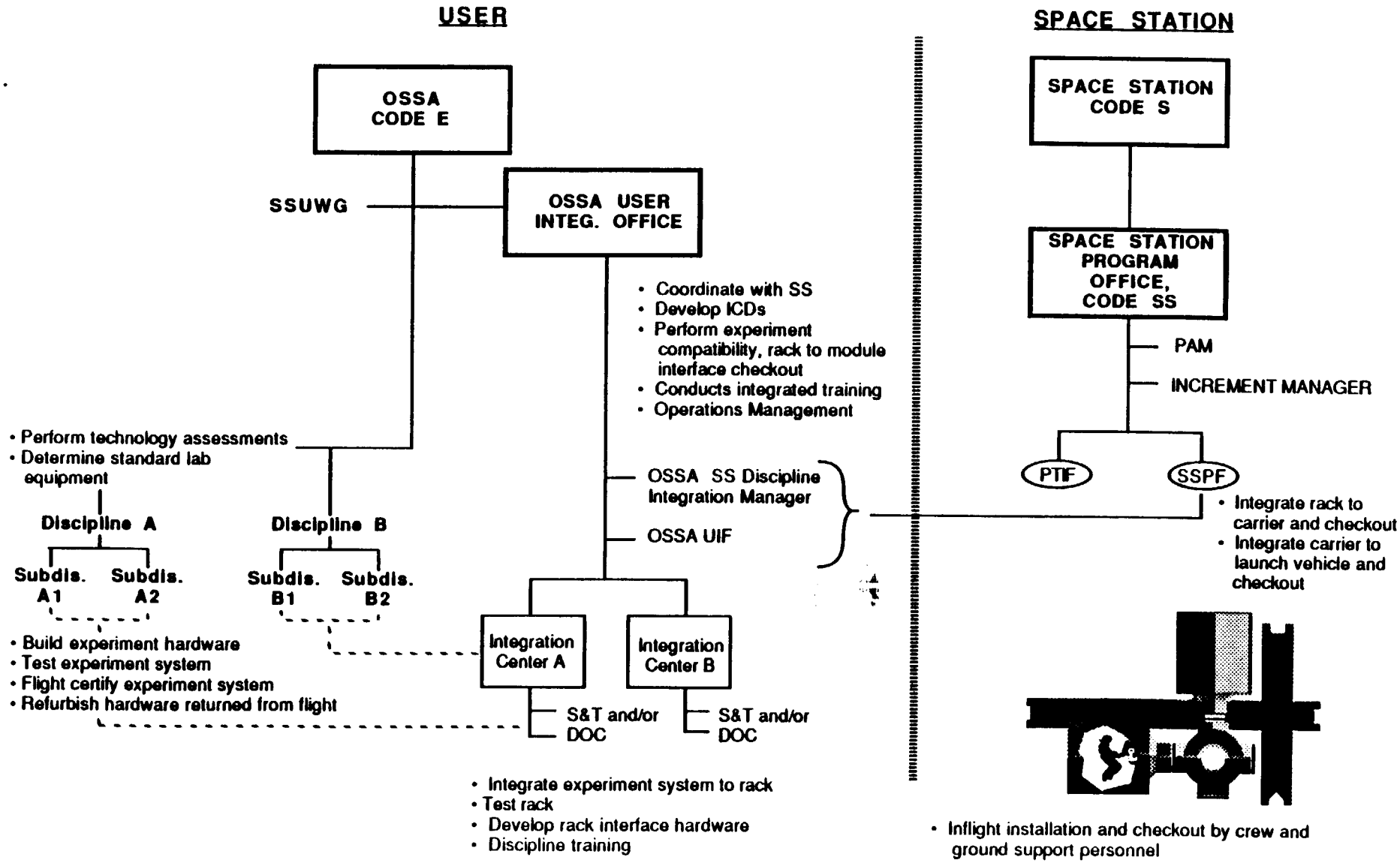


Figure i-3

OSSA SPACE STATION HARDWARE INTEGRATION FLOW

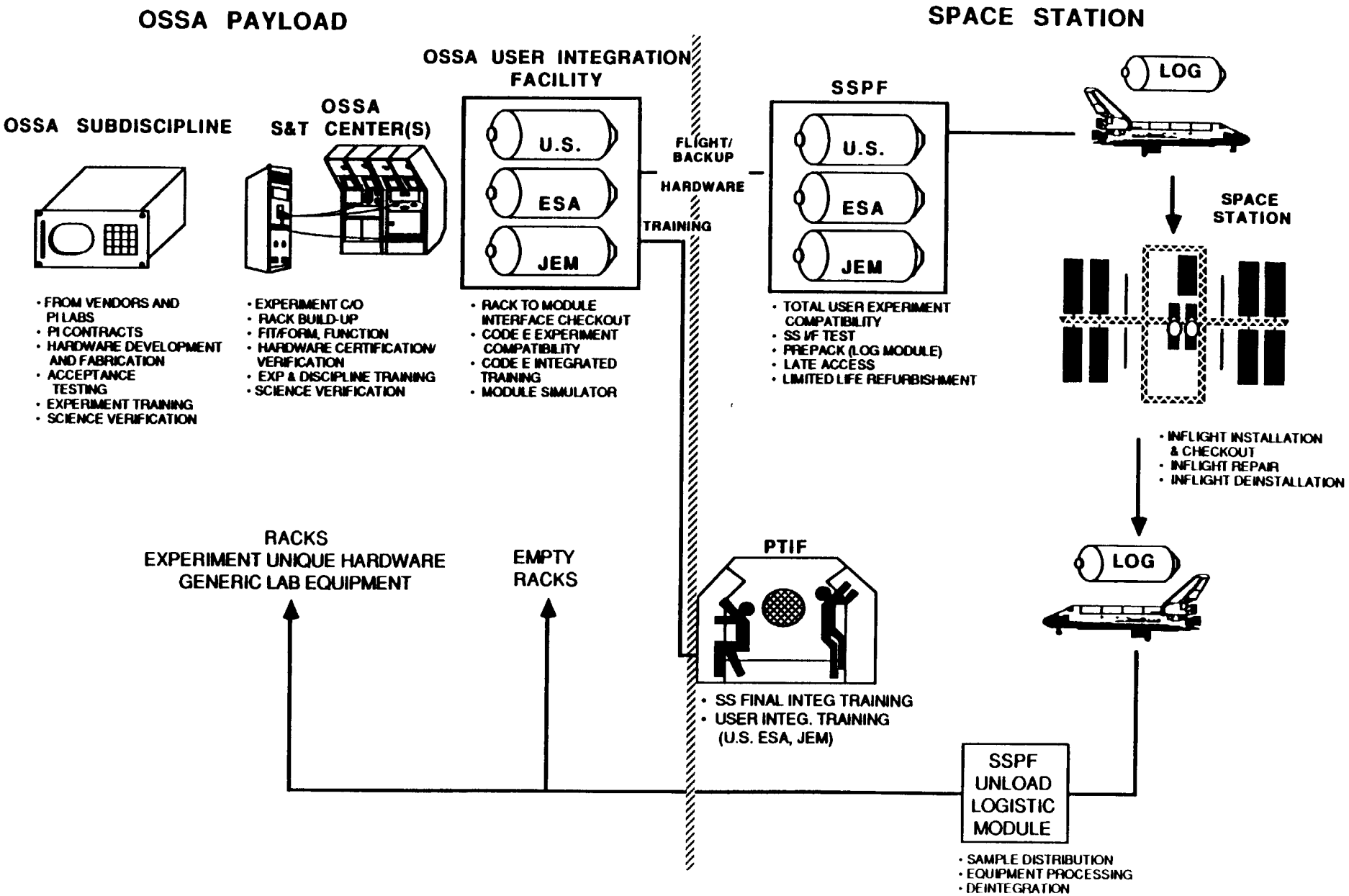


Figure i-4

SSOTF REAL-TIME OPERATIONS MANAGEMENT CONCEPT

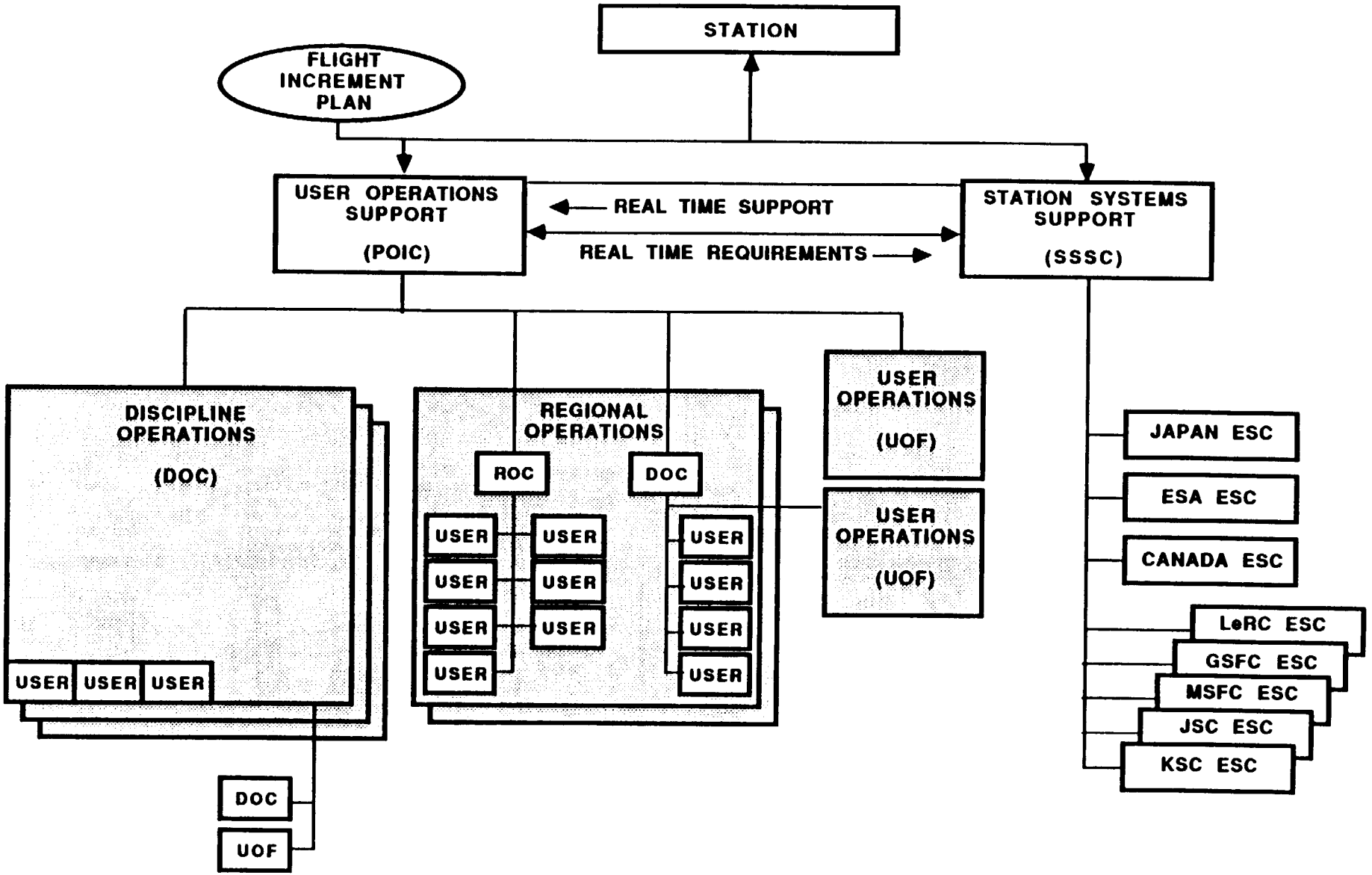


Figure i-5

POIC ORGANIZATIONAL STRUCTURE

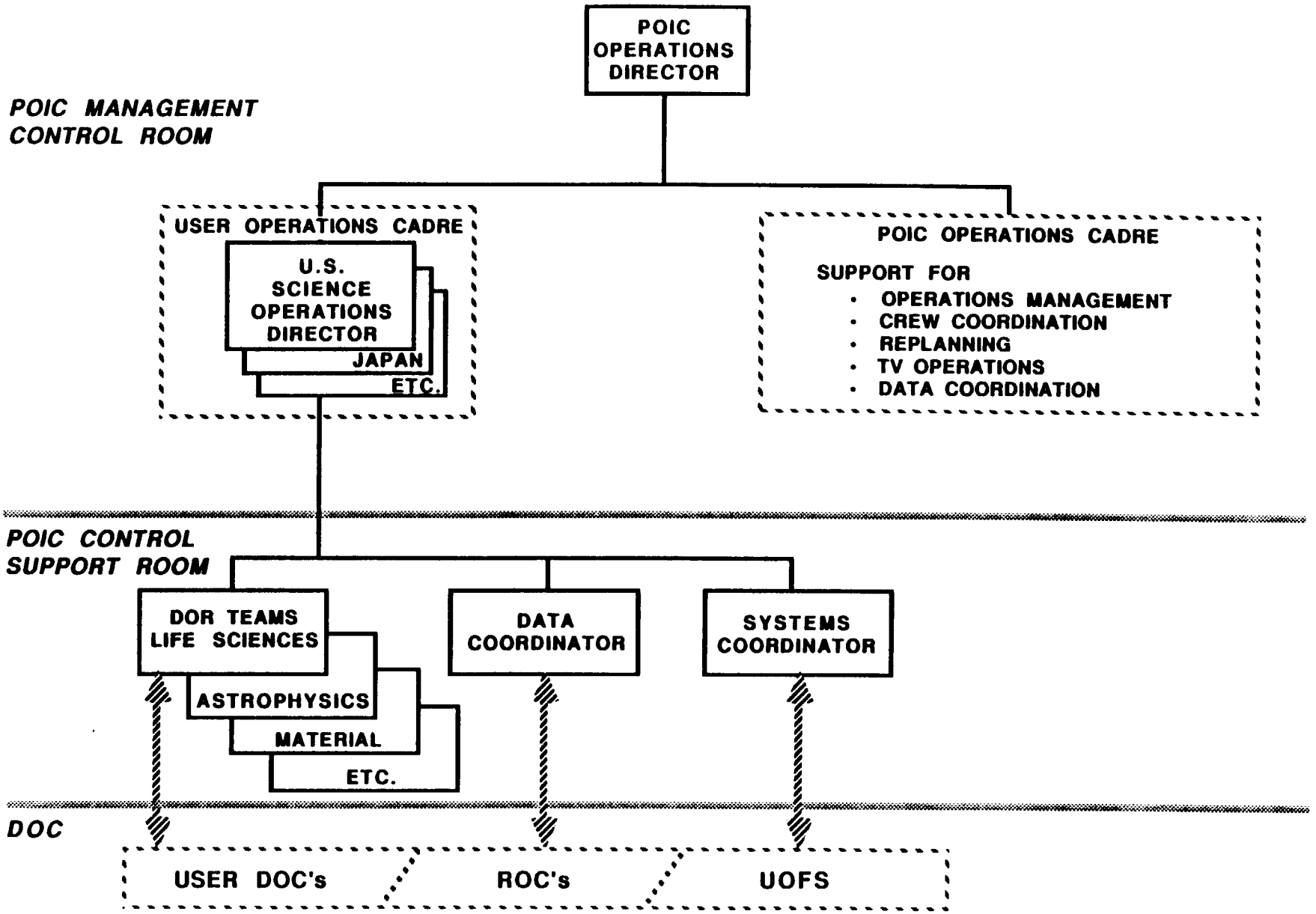


Figure i-6

1. Promotion of a single point advocacy between the USER Community (including internationals) and the Space Station program organization for user requirements and resource allocation. OSSA will be integrally involved in this process. Also provides single point advocacy for OSSA with Space Station program organization during payload ground integration and operations activities.

2. Assurance of maximum science and technology return to OSSA users.

3. Assurance of maximum on-orbit resource utilization for experiment operations while minimizing on-orbit hardware repair and maintenance.

    - Trade-off between ground preparation with facilities, training and simulation adequate to insure efficient use of resources inflight, particularly crew time.

    - Capability for inflight anomaly resolution, trouble shooting and on-orbit ground support.

Space Station Science Integration Management Study Final Report

Introduction
Section 1.0

1.0 INTRODUCTION

1.1 GENERAL INFORMATION

For the next three decades, the Space Station Program will be a major NASA program. This program offers both domestic and foreign User communities (science, commercial, government, academia, etc.) the capabilitiy for conducting manned and unmanned space science, applications, and technology research in a variable-g environment for extended periods of time. The manned base capability consists of pressurized modules provided by the U.S., European Space Agency (ESA), and Japan for living and conducting investigations. Resource nodes connect the modules and provide additional pressurized working space. Unmanned space science and applications capability is provided by co-orbiting platforms and polar orbiting platforms provided by the U.S. and ESA. Payload development, integration, and operations activities for the Space Station era are an enormous undertaking and require new and innovative techniques for managing, planning, and developing payloads that fully utilize the capabilities the Space Station will offer the User community.

1.2 PURPOSE/SCOPE

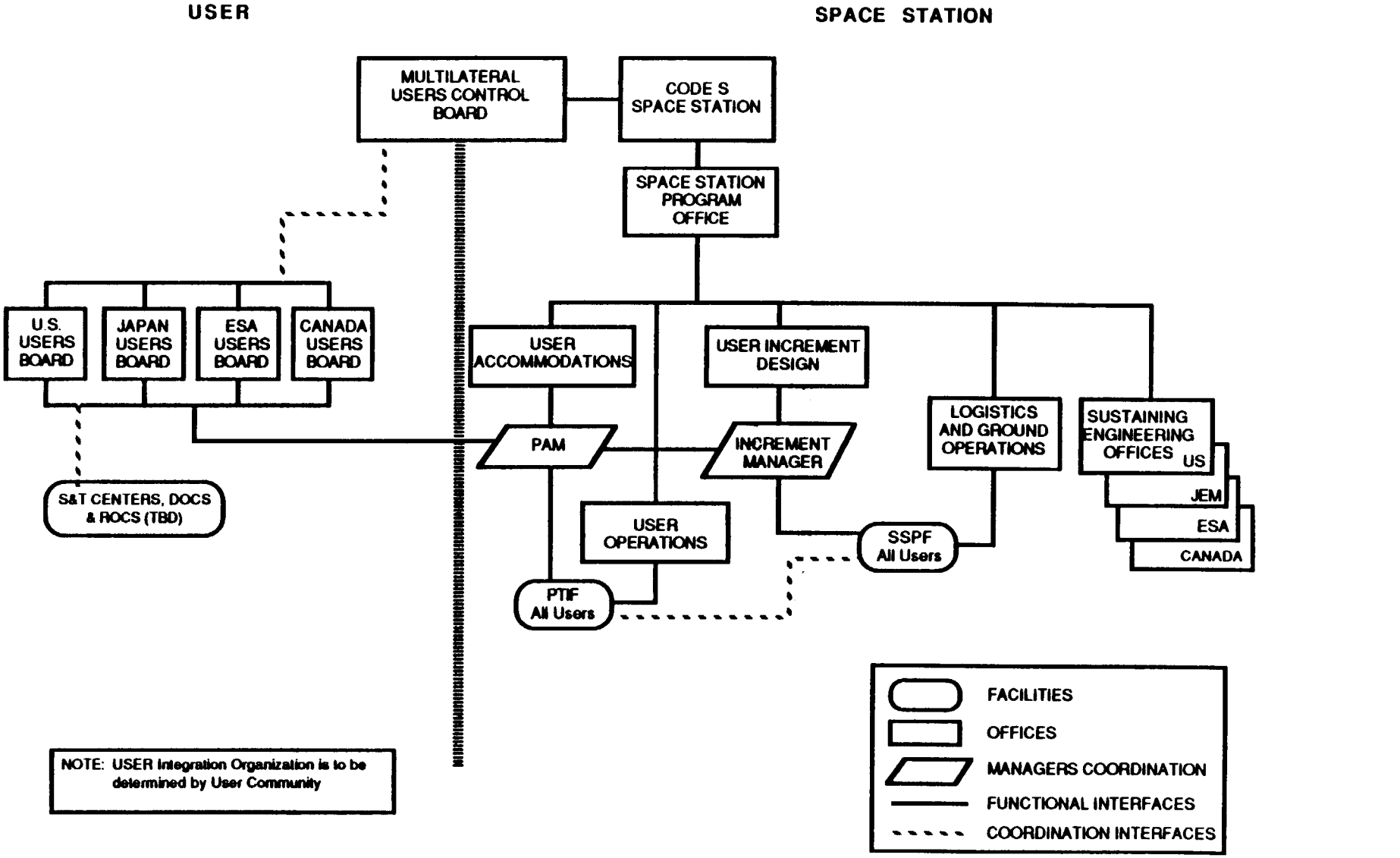
This study was performed to provide the Office of Space Science and Applications (OSSA) with a concept and recommendations for managing and implementing the major integration activities for OSSA science payloads during the Space Station era. This study is limited to defining the roles and responsibilities for OSSA science payload Users who will interface with the Space Station organization. The recommended concept for a Space Station management organization, developed by the Space Station Operations Task Force (SSOTF), is used throughout this study. However, the SSOTF Study does not identify a payload Users organization below a Multilateral Control Board (an international board consisting of representatives from participating countries that is responsible for Station resource allocations and 5 year strategic planning for both USERS and Station).

The SSOTF recommendations deal with User functions only to the extent of defining interface requirements from the Space Station program perspective (reference Figure 1-1). This study begins at that point and identifies possible User organization integration management concepts for conducting payload integration activities for User payloads. It then defines an optimum integration management concept for OSSA payloads. Emphasis is given to payloads and science payloads (life sciences, materials sciences, etc.) that are accommodated in the Space Station pressurized modules with some considerations made for payloads attached to the structure.

The term "integration" as used in this study includes all the necessary functions, activities, and elements of a payload that must be combined (brought together), verified, and certified to insure that a mission or flight increment can be launched, can accomplish inflight goals and objectives, and can be returned to Earth successfully. These activities are not limited to the hardware integration activities that are normally thought of when the term "payload integration" is considered. They also include:

- Science Integration and Management
- Resource Allocation/Configuration Management
- Flight Increment Planning and Design
- Stowage Integration
- Operations Management

SSOTF SS INTEGRATION PROCESS CONCEPT



SSOTF concept focuses on the integration process between Space Station to highest user element (U.S. and International) level. It does not address user organizations within the U.S.

Figure 1-1

- Logistics Management
- Data Distribution and Archival

1.3 Study Approach

The basic approach taken to develop the overall integration management concept for OSSA consisted of five tasks. The study team first identified the major functions and activities involved in designing and developing a complement of scientific payloads from start to finish (i.e., from announcement of opportunity to postflight reporting). This included defining the integration functions and activities that are required to successfully fly a Shuttle/Spacelab mission and identifying how these functions and activities are presently being managed and performed. Second, the unique characteristics of Space Station that will affect payload development and integration functions and activities were identified.

Third, various organizational concepts for planning, implementing, and managing the major payload activities involving the Space Station user were developed using the extensive experience base of the study team members. At the conclusion of this study phase, results of the SSOTF Study became available and provided the basic Space Station Operations Concept. A review of this study concluded that the SSOTF Study recommended an organization and facilities for Space Station Management but left undefined the payload user's Management organization and facilities. Concepts and recommendations of the SSOTF Study were accepted and incorporated into this report.

The fourth task involved developing a set of criteria for selection of an optimum integration management concept for OSSA as a science user of the Space Station. Based on these criteria, an optimum OSSA Space Station science payload integration management concept was selected and defined. During this phase of the study, the Space Station Science Operations Management Concepts Study (SSSOMC) was published. The study team reviewed the SSSOMC report and found recommendations to be compatible with concepts previously developed during this study. This report concludes by recommending a management concept for planning and implementing OSSA payload user integration activities with the Station. Figure 1-2 illustrates the principal tasks, products, and schedule for this study.

1.4 GLOSSARY

Definitions of key terminology used in this report are contained in appendix A, Glossary.

1.5 STUDY ASSUMPTIONS

The following are the basic assumptions used by the team in developing the integration management concepts for this study.

- The SSOTF recommendations and definitions for international participation and overall Space Station roles and responsibilities as released in the final draft report dated August 25, 1987 are used in this study.
- Study concepts are designed for integration management in support of Space Station activities beginning at PMC through mature operations.
- Strategic and overall Space Station planning is centralized in the U.S. at the NASA Headquarters Office of Space Station. International partners participate at all levels, as appropriate.
- A Space Station User Utilization and Operations organization is responsible for user accommodations and integration requirements with Space Station.

SPACE STATION SCIENCE FEASIBILITY STUDY SCHEDULE

FY87

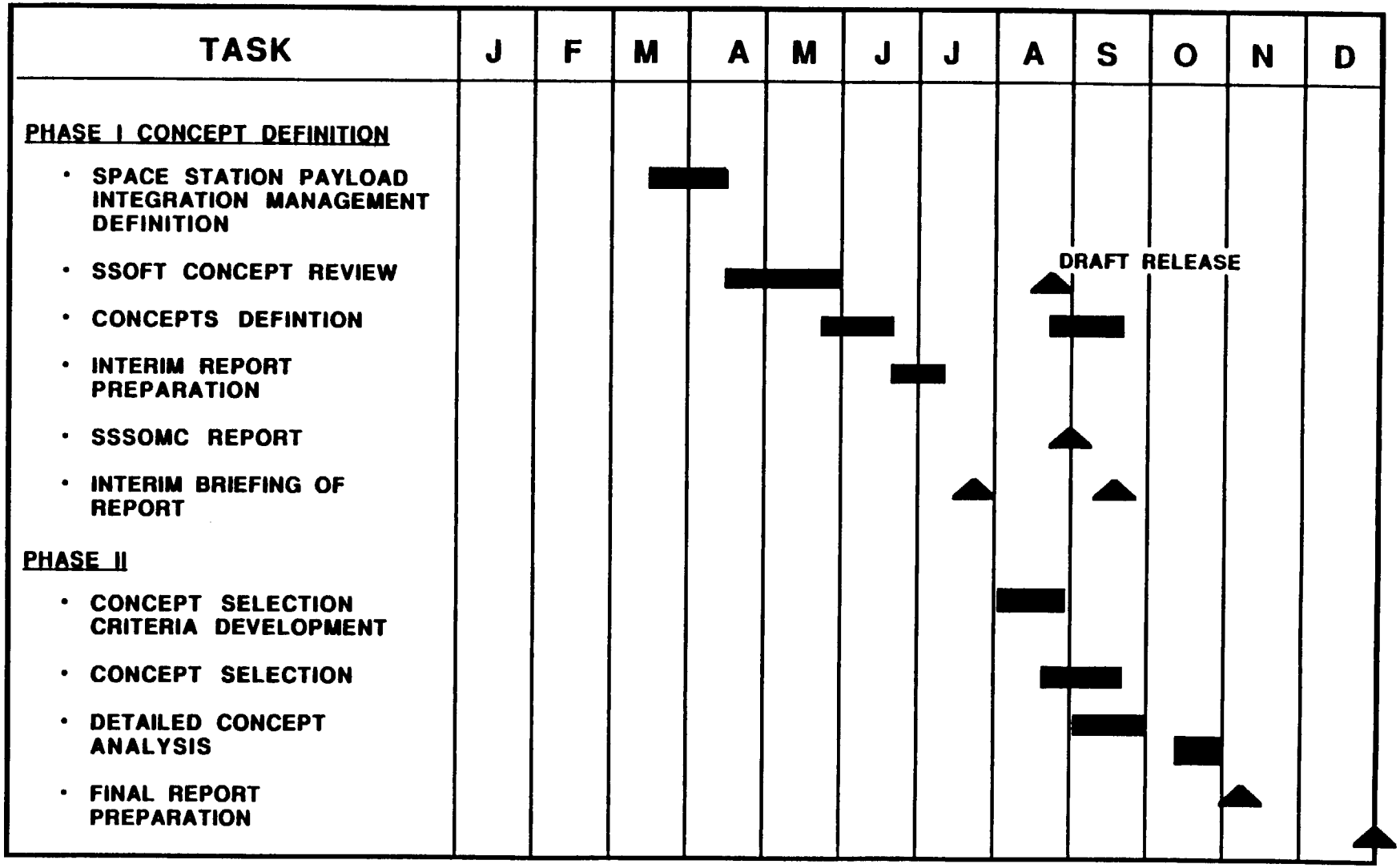


Figure 1 - 2

- SSOTF recommendations deal with User functions only to the extent of defining the interface requirements from the Space Station Program's perspective. Users are responsible for developing User organizational structure, roles, and responsibilities for managing and conducting payload planning, development, and integration activities for User payloads.
- Science payloads are distributed in the pressurized U. S. laboratory, ESA, Japanese Experiment Modules, and nodes attached to the structure.
- Elements: — Managed By:
  - U.S. Laboratory Module — MSFC
  - European Space Agency Module — ESA
  - Japanese Experiment Module (JEM) — Japan
  - Logistics Module — KSC
  - Nodes — JSC
  - Habitability Module — MSFC
  - Attached Payloads and Platforms — GSFC
- Space Station elements are operated as an integrated entity.
- Crew selection and training are conducted jointly as an international team.
- U.S. primary Users of Space Station are:
  - Code E (Office of Space Science and Applications)
  - Code R (Office of Aeronautics and Space Technology)
  - Code C (Office of Commercial Programs), includes commercial Users
  - DoD (Department of Defense)
  - Code M (Office of Space Flight)
- Generic and functional accommodations that Space Station provides to the User community include:
  - Increment Change Manager for Space Station User interface
  - Payload Training Integration Facility (PTIF) for final integrated training activities for all payload users
  - Payload Accommodation Managers (PAMs) to act as User single point-of-contact with Space Station for user accommodation requirements.
  - Space Station Processing Facility (SSPF) which houses the prelaunch processing activity for all Space Station hardware and payloads to be transported to orbit and which contains a Master Interface Facility (MIF).
  - Hardware functional, fit, and form checks for payload users at the launch site.
  - Minimal support for payload user integrated training activities in the PTIF.

1.6 Summary of Report Contents

Section 2.0 discusses the unique characteristics of Space Station that are different from previous manned programs and that impact the integration process. It also identifies general goals for which the user community should strive when planning for Space Station.

A description of the various integration management concepts initially developed by the study team to accommodate integration functions and activities is provided in section 3.0. The concepts are based on management control and location of facilities that are required for payload integration activities.

Next, the criteria that was used to select the optimum integration management concept for OSSA are defined. Three major areas of emphasis are 1) criteria for science

planning and resource allocation management, 2) payload ground integration and implementation activities, and 3) real-time operations management.

Section 4.0 contains a detailed description of how the overall integration process for OSSA (within the selected concept) can be planned, managed, and controlled for Space Station. An organization for each area with roles, responsibilities, and methods (documents) for communicating within the organization and with Space Station is identified. Specific areas include 5 year and 2 year planning activities for resource allocation, science selection and prioritization, and detailed flight increment planning which includes analytical integration, increment design, data management, and operations.

Other areas addressed are experiment and hardware development, hardware integration / verification, operations, training activities and facilities requirements.

Recommendations for consideration in planning and implementing recommended concepts for the Space Station Program are presented in Section 5.0. Included are suggested roles and responsibilities for JSC to assist OSSA in science payload integration activities for Space Station.

1.7 RELATED ACTIVITIES/STUDIES

Related studies and references used by the team in the development of this report consisted of current Space Station studies being conducted by Space Station organizations, USER organizations and contractor support personnel. Other references include existing documentation on Shuttle Integration activities and historical documentation for Apollo and Skylab programs.

Current Space Station studies utilized include:

1) OSS-2627 "Objectives and Status of the Space Station Operations Task Force," October 30, 1986.
2) JSC-32040 87-FM-12 "Preliminary Integrated Operations Task Force," August 14, 1987.
3) "Summary Report of the Space Station Operations Task Force," August 4, 1987.
4) "Space Station Science Operations Management Concepts Study," August 1987.
5) "Master Integration Facility Study," December 15, 1986.
6) JSC 30286, "Space Station Operations Process Requirements," October 31, 1986.
7) JSC-30253, "Space Station Flight Support Equipment and Orbital Support Equipment Integration Process Requirements Document."
8) JSC-30,000, Section 2, Part 2, Revision B. "Space Station Program Definition and Requirements;" Section 2: Programs Management Requirements, Part 2: Work Breakdown Structure
9) "Space Station Mission Requirements Data Base," January 1987.

Other related Shuttle documentation utilized are listed in the bibliography in Appendix B.

Space Station Program
Section 2.0

2.0 THE SPACE STATION PROGRAM

2.1 UNIQUE CHARACTERISTICS

The Space Station's closest historical analogies for manned spaceflights are the Skylab and recent Spacelab Programs. The pressurized Skylab and Spacelab modules were developed as general purpose support facilities for performing science and technology research over limited periods of time. The requirement that the Space Station must serve a wider range of customers for a longer period of time sets it apart from these previous programs. Other unique characteristics of the Space Station that affect the way the User community plans, develops, interfaces, and integrates its payload with the Space Station include:

- Continuous operations with 90 to 180 days for each flight increment require continuous ground operations support to monitor /manage these inflight operations.
- On-orbit hardware integration, checkout, maintenance, deintegration, and storage require a re-evaluation of how crew training, crew activity planning, inflight logistics management, and hardware development and integration should be performed to optimize crew time in flight.
- International partners must be considered in allocation, real-time operations management, locations and management control for ground facilities, and international science issues.
- International crew complement influences the crew selection process, training, crew utilization inflight for User investigations, and payload operations management.
- Logistics and resupply affect up / down load requirements, log module integration / deintegration activities, and on-orbit transition / storage and waste management.
- Operations are complex since Space Station operations are projected to span three decades and need to be cost effective.

2.2 SPACE STATION USER PAYLOAD MANAGEMENT OBJECTIVES

When developing a concept for Space Station user community payload planning, development and integration activities, the optimal use of resources and inflight crew time should influence all phases. The Users' payload integration management philosophy and goals for Space Station should include:

- Maximizing the science and technology return to the Users.
- Maximizing on-orbit resource utilization for experiment operations; minimizing on-orbit hardware repair and maintenance.
- Trading off ground preparation and operations training for optimum inflight operations.
- Insuring experiment and hardware compatibility with extended Space Station operations.
- Minimizing cost to Users by developing and maintaining standard interfaces, promoting modularity, and developing and cross utilizing generic laboratory equipment.
- Coordinating the replanning of on-orbit operations in real-time to insure optimum use of allocated resources.

Overall, the User community should unite its interests and promote single point advocacy between the user community and the Space Station organization during all phases of payload accommodations development, integration, and operations.

USER Integration Management
Concepts/Options Overview
Section 3.0

3.0 USER INTEGRATION MANAGEMENT CONCEPTS/OPTIONS OVERVIEW

3.1 GENERAL DESCRIPTION

Six concept options were developed initially by the study team for analysis. They include the following:

1) The Multinational Payload Integration Management Facility Concept.
2) Centralized U.S. User Integration Management Facility Concept.
3) OSSA User Integration Management Facility Concept.
4) Discipline User Support to the Space Station Integration Management Concept.
5) Project Level Support to Space Station Integration Management Concept.
6) Distributed Integration Management Facility Concept.

These concepts identify the management level where the overall integration management organization and facilities for hardware integration, training, and real-time operations support activities are located to conduct and verify user payload compatibility prior to final interface checkout with Space Station. The major difference in each concept is the level within NASA's organizational structure where these facilities are managed and controlled. It is assumed that for those concepts where the level of management and control is at NASA Headquarters, the execution functions are performed at a designated lead NASA field center. A summary of each of the six concepts follows.

3.2 MULTINATIONAL PAYLOAD INTEGRATION MANAGEMENT FACILITY CONCEPT

The Multinational Payload Integration Management Facility Concept focuses on a centralized USER facility managed and controlled by an International User Integration Office. Reference Figure 3-1. User payload activities for the USER community including those of the international partners (science planning and resource allocation, hardware, integration, operations management) are planned, managed and implemented by this office and conducted in this facility prior to final Space Station interface checkout at the launch site. Basic assumptions used in the development of this concept include the following:

- The Space Station organization is the same as recommended by the SSOTF. However, final payload integrated training for all users is managed and controlled by the USER community in an International Payload Integrated Training Facility (PITF) instead of the Space Station managed Payload Training Integrated Facility (PTIF) recommended by the SSOTF.

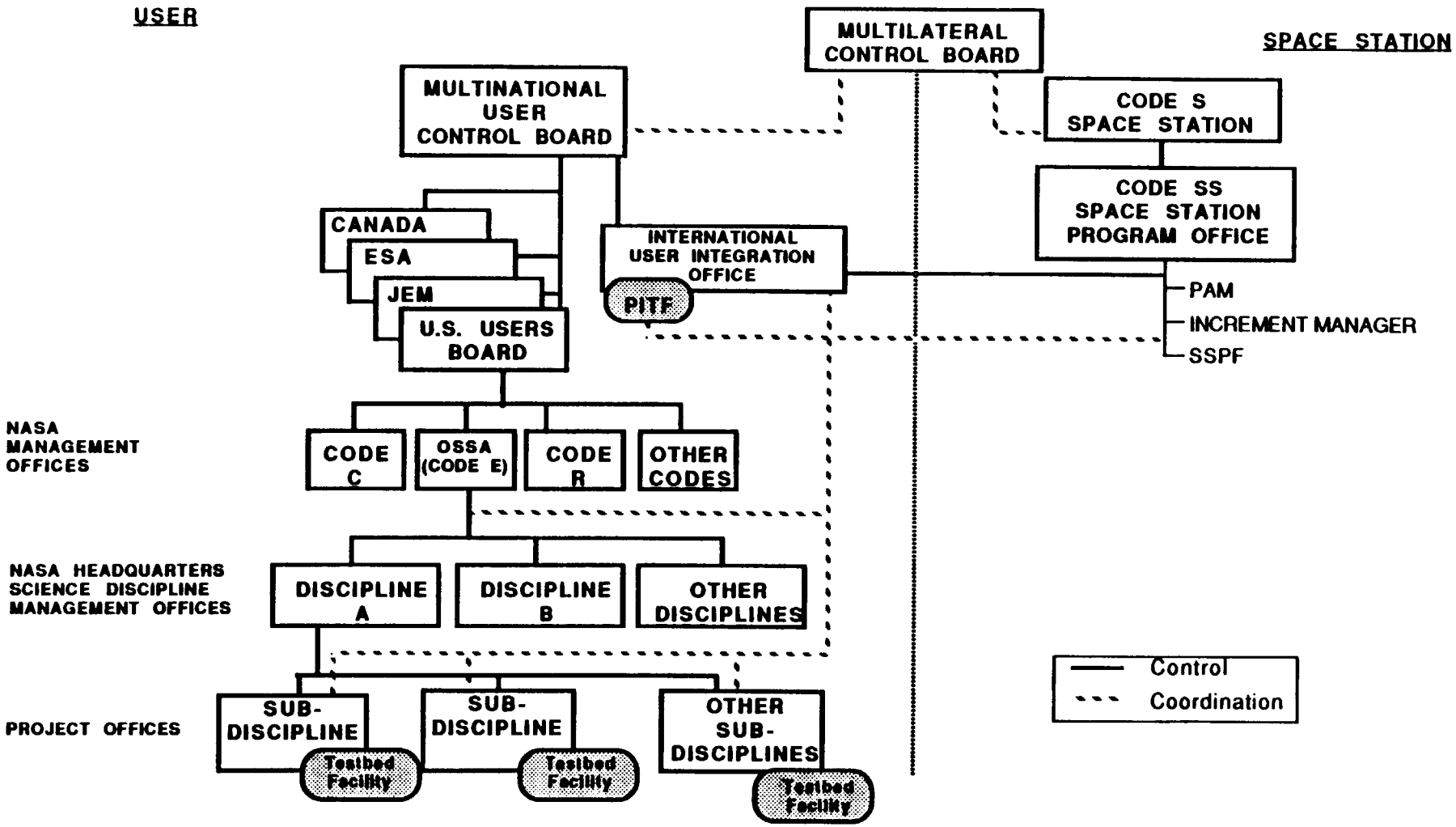
- The PITF is managed and controlled by an international user integration office at NASA Headquarters. Accommodations and requirements for use of the facility are negotiated through this office.

- All user elelments payloads are verified and certified as a single payload in the PITF prior to final interface checkout with Space Station.

- Discipline offices, international partners use and support as appropriate hardware integration and training activities at the facility.

- Users provide integrated racks to the PITF and to Space Station.

MULTINATIONAL PAYLOAD INTEGRATION MANAGEMENT FACILITY CONCEPT



Concept focuses on a centralized user facility managed by NASA Headquarters where all international user payload activities (hardware/rack integration, verification/certification) and integrated training activities are conducted prior to final Space Station interface checkout at launch site. This facility could be an S&T Center recommended by SSOTF.

Figure 3 - 1

A summary of roles and responsibilities for each level of management depicted in this concept follows.

Multinational User Control Board

- Consists of representatives from USER Community (U.S. and international partners)
- Allocates allotted Station USER resources to international partners
- Develops the USER community 5-year Strategic Planning for Station which projects overall user requirements, goals, and policies for station resources

International User Intergration Office

- Manages Payload Integration Training Facility (PITF)
- Acts as single point advocacy for all user payload requirements with Space Station
- Performs analytical integration, flight increment design, and compatibility analysis for all user requirements with Space Station
- Manages and coordinates hardware integration, training activities and schedules for users (conducts integrated training activities)
- Provides cadre of ground support personnel to support POIC during real-time operations

Partner's Space Station User Boards

- Develops the two year tactical operations plan and allocates resources to its users
- (Note: each international partner will have a Users Board)
- Performs partner science coordination/compatibility
- Selects science and experiments for partners as part of Station Strategic and Tactical Planning activities

OSSA

- Allocates resources for the OSSA science discipline organizations
- Solicits/selects OSSA payload experiments for flight
- Resolve conflicts and problems within OSSA
- Recommends crew selection criteria for Space Station crew selection process

Discipline Management Office

- Allocates resources within the discipline organizations
- Coordinates requirements compliance and compatibility for discipline payload
- Supports analytical and hardware integration and training activities at the PITF
- Determines discipline integration and generic hardware laboratory equipment requirements

Subdiscipline/Testbed Facilities

- Monitors PI contracts
- Develops experiments and experiment hardware
- Conduct experiment training activities
- Performs integration and crew training activities at PITF
- Performs experiment checkout/rack build-up
- Performs science verification
- Performs baseline data collection

The payload hardware flow for this concept is depicted in Figure 3-2. A preliminary analysis of this concept revealed pros and cons as described in Table 3.1. The concept provides for 1) single point advocacy for the USER community with Station and 2) a facility to perform payload compatibility and verification activities. The USER community does not have to rely on Station facilities or be impacted by Station ground facility schedules. However, no NASA organization currently exists which can support the total USER community. The cost of the PITF will be tremendous to the USER community. Multinational political implications could also impact the successful implementation of this concept.

3.3 CENTRALIZED U.S. USER INTEGRATION MANAGEMENT FACILITY CONCEPT

In the centralized U.S. User Integration Management Facility Concept, U.S. User payload integration activities are managed by a U.S. User Integration Office at NASA headquarters (reference Figure 3-3). After resource allocations are made by the Multilateral Control Board, U.S. user payload integration activities are planned and implemented in a U.S. User Integration Facility (USIF). Basic assumptions used to develop this concept include the following:

- The USIF provides interface and verification capabilities for all modules to which a U.S. User may be assigned. It will also provide high fidelity flight-like accommodations for U.S. User training and flight activities.
- USIF is managed and controlled by a NASA Headquarters user organization, (preferably OSSA).
- Accommodations and requirements for use of the facility are negotiated through this office.
- U.S. OSSA Science and Project Discipline Offices use and support as appropriate the USIF for hardware integration and training activities.
- U.S. user discipline experiments are integrated to the rack level.
- Space Station has an organization which performs payload integration analyses for the total modules.

Roles and responsibilities for each level of management in this concept follow.

Multilateral Control Board

- Allocates resources to Station users.
- Performs Station 5 year Strategic Planning

MULTINATIONAL PITF PAYLOAD HARDWARE FLOW
(PRESSURIZED MODULES ONLY)

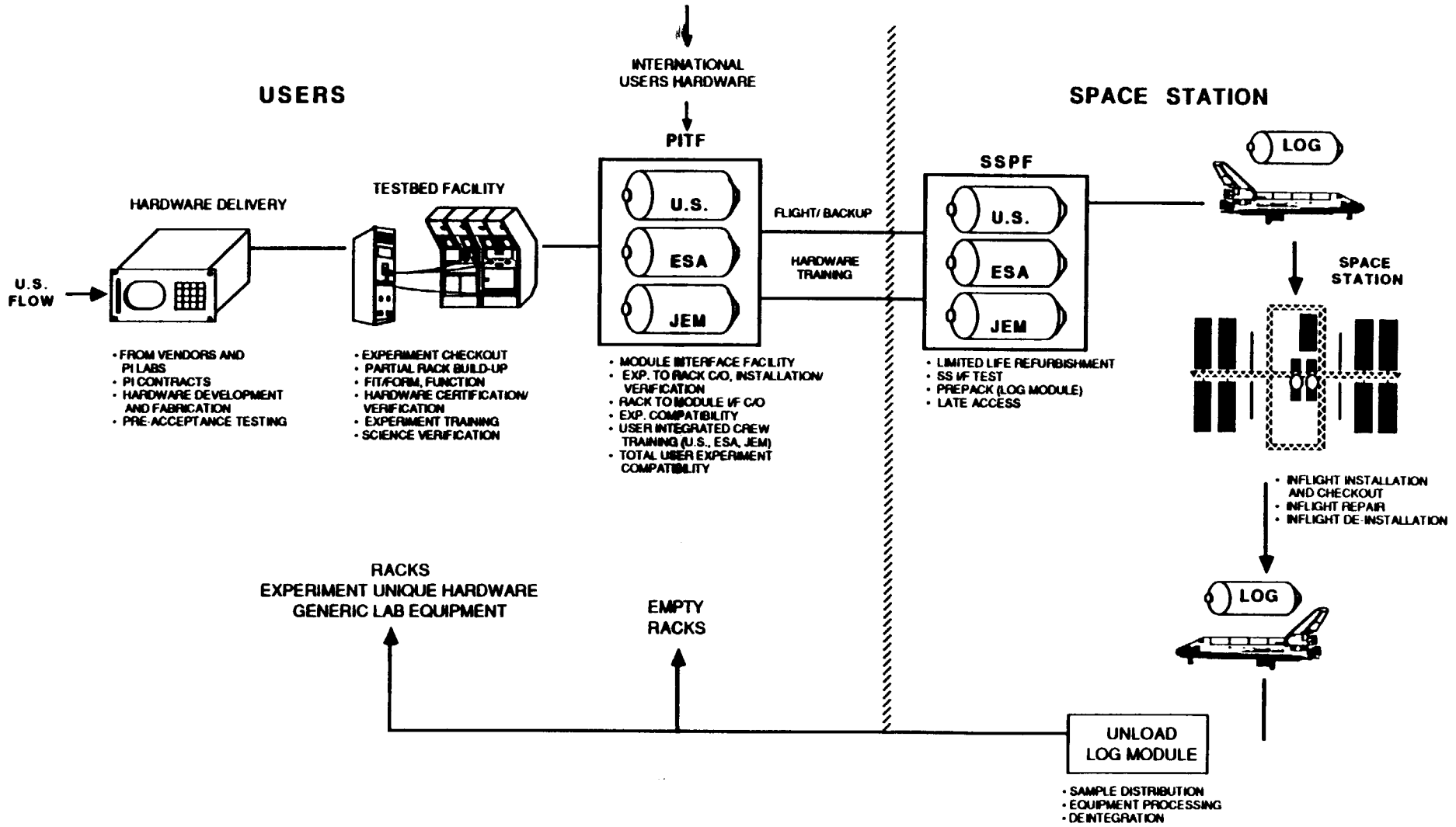


Figure 3-2

PROS

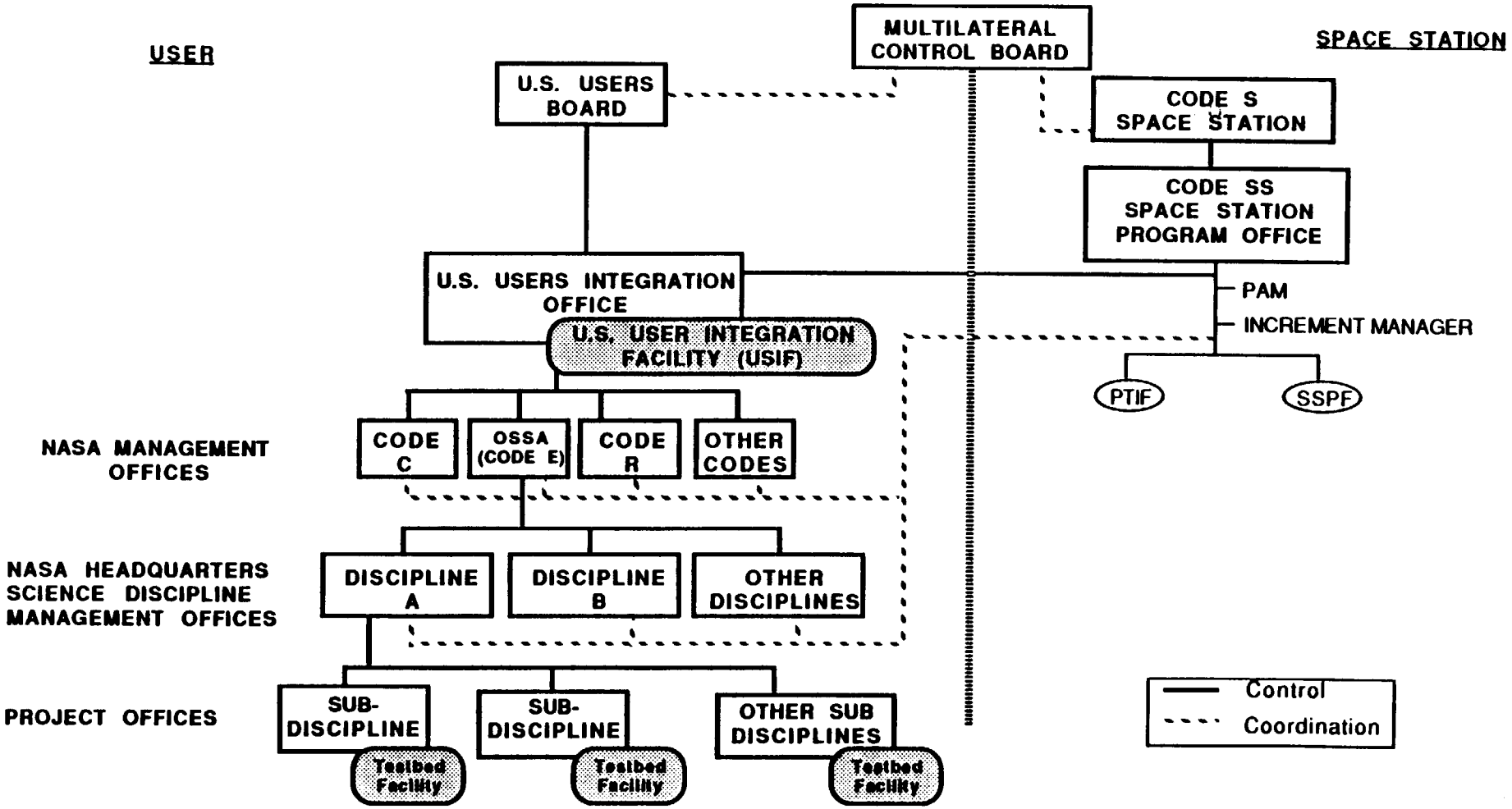
- Allows single point advocacy for all USERS (including internationals) with Space Station for resource allocations and crew selection requirement inputs.
- Allows user control of payload to conduct science and payload integration, verification and compatibility activities.
- Provides capability for USERS to verify Payload compatibility prior to interface checkout by Space Station at the launch site; does not have to rely or be impacted by Space Station facilities and schedules.
- Provides capability to support on-orbit replanning and anomaly troubleshooting for total payload.
- Allows capability for crew (both flight and ground) to perform integrated training on total payload.
- Provides more effective operations management for real-time operations preflight and inflight

CONS

- Requires an international user organization which does not currently exist to support and manage all USER integration activities (including internationals)
- Cost of integration facility will be tremendous to the USER community
- Scheduling conflicts for use of facility by individual USER elements to support hardware and integrated crew training activities
- Multinational Political implications will pose serious financing and management problems

Table 3.1 Multinational Payload Integration Management Facility Concept-Pros/Cons

CENTRALIZED U.S. USER INTEGRATION MANAGEMENT FACILITY CONCEPT



Concept focuses on a centralized user facility managed by NASA Headquarters where all U.S. user payload activities (hardware/rack integration, verification/certification) and integrated training activities are conducted prior to final Space Station interface checkout at launch site. This Facility could be S&T Center recommended by SSOTF.

Figure 3 - 3

U.S. Space Station USER Board

- Performs U.S. User Science coordination/compatibility
- Allocates resources to users within the U.S.
- Selects candidate U.S. Science and experiments for SS participation.

U.S. USER INTEGRATION OFFICE

- Acts as single point advocate for U.S. User requirements with Space Station
- Manages and maintains USIF
- Performs analytical integration; flight increment design, and compatibility analysis for U.S. user requirements with Space Station
- Manages and coordinates training activities and schedules for U.S. Users (conducts U.S. User integrated training activities)
- Provides a cadre of ground support personnel to support the POIC during flight operations
- Performs integrated science verification activities.
- Manages data acquisition and distribution for U.S. Users

OSSA MANAGEMENT OFFICE

- Allocates resources to OSSA science disciplines
- Solicits experiments, makes recommendation for flight
- Resolves conflicts and problems between OSSA Science Disciplines
- Recommends crew selection criteria for Space Station crew selection process

DISCIPLINE MANAGEMENT OFFICE

- Allocates resources to subdiscipline organizations subject to OSSA approval
- Coordinates requirements compliance and compatibility for discipline payload elements
- Supports analytical and rack-to-module integration activities at USIF
- Determines generic laboratory equipment for each discipline

Subdiscipline/Testbed Facilities

- Evaluates proposed experiments
- Monitors PI contracts
- Develops experiments and experiment hardware
- Conducts experiment training activities
- Performs integration and crew training activities at USIF
- Performs experiment checkout/rack build-up
- Performs experiment verification
- Performs baseline data collection

This concept emphasizes single point advocacy with Space Station for U.S. users only. Total user payload compatibility, if performed, would rely on Space Station facilities and organizations. Hardware flow and pros and cons for this concept are found in Figure 3-4 and Table 3.2, respectively.

USIF PAYLOAD HARDWARE FLOW
(PRESSURIZED MODULES ONLY)

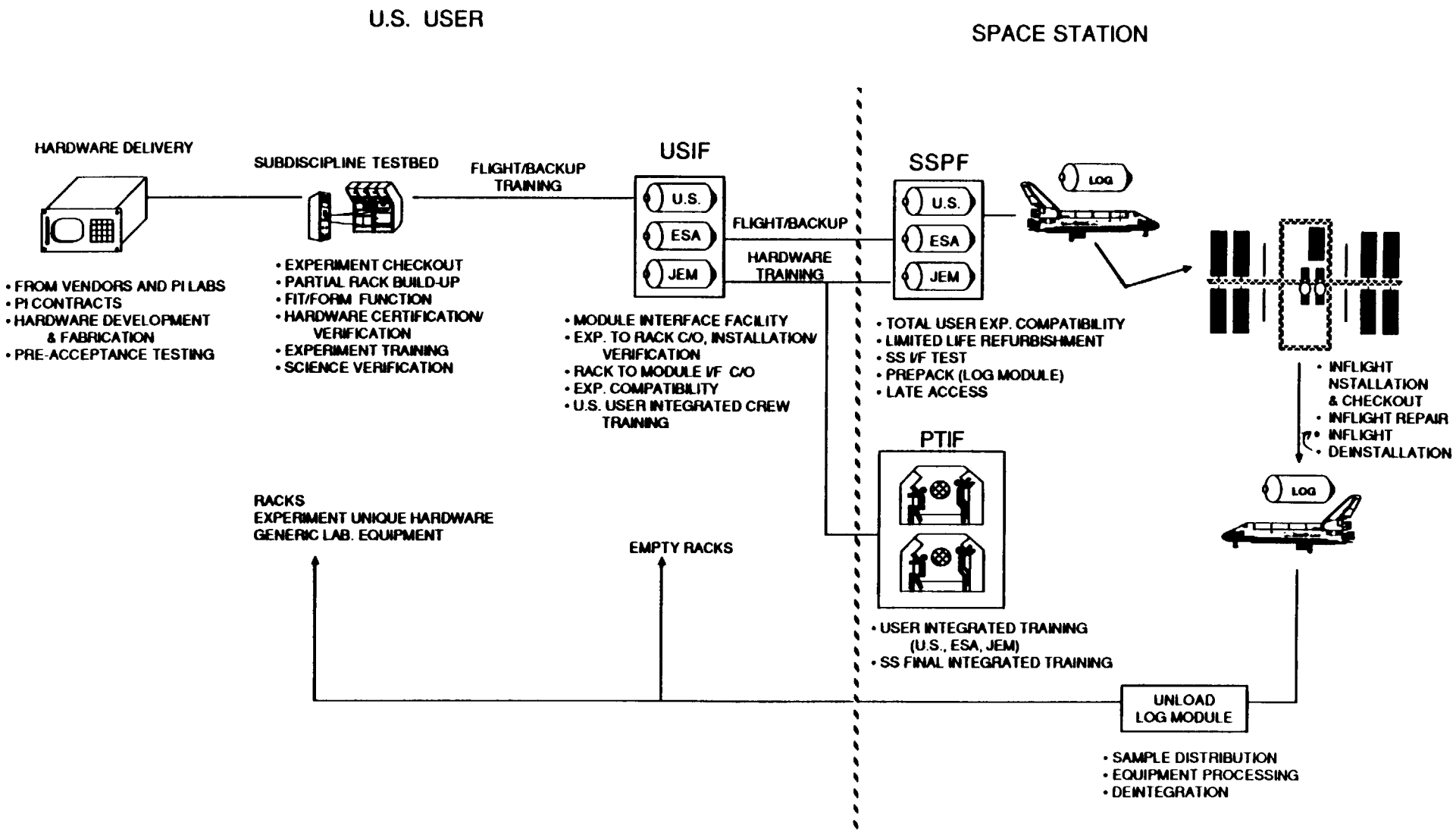


Figure 3-4

PROS

- Allows single point advocacy for U.S. USERS for resource allocation, crew selection requirements input, and science requirements
- Provides capability for U.S. users to verify U.S. payload compatibility prior to interface checkout with other users by Space Station at the launch site.
- Provides capability to support on-orbit replanning for U.S. payloads.
- Allows capability for crew to perform integrated training on U.S. payloads.

CONS

- NASA USER organization does not currently exist to support and manage all U.S. user integration activities.
- Does not provide capability to verify total USER payload compatibility prior to interface checkout by Space Station at the launch site.
- Cost of facility will be U.S. user cost.
- If total payload compatibility is verified, it would be conducted by Station organization in Station Facilites subject to station scheduling constraints.
- Does not provide adequate capability to support on-orbit replanning for total payload by the users.
- Does not allow capability for USER to provide training on total payload prior to Station integration training activities.

Table 3.2 Centralized U.S. USER Integration Management Facility Concept-Pros/Cons

3.4 OSSA USER INTEGRATION MANAGEMENT FACILITY CONCEPT

The OSSA User Integration Management Facility concept focuses on an OSSA integration organization which manages and implements payload integration activities at an OSSA integration facility. Resource allocations are made by the U.S. SS User's Board (refer to Figure 3-5). Assumptions used in the development of this concept include the following:

- OSSA is responsible for the majority of U.S. Science Payloads.
- The OSSA User Integration Facility is managed and controlled by OSSA but located at designated field center.
- Accommodations and requirements for use of the facility are negotiated through OSSA.
- OSSA Science Discipline Offices and Subdiscipline Offices use and support as appropriate hardware integration and training activities at the facility.
- Discipline experiments are integrated to the rack level at designated S&T centers for each discipline.

Roles and responsibilities for each management level for this concept follow.

Multilateral Control Board

- Same function as described in previous concept

U.S. SS USER BOARD

- Same as described in previous concept

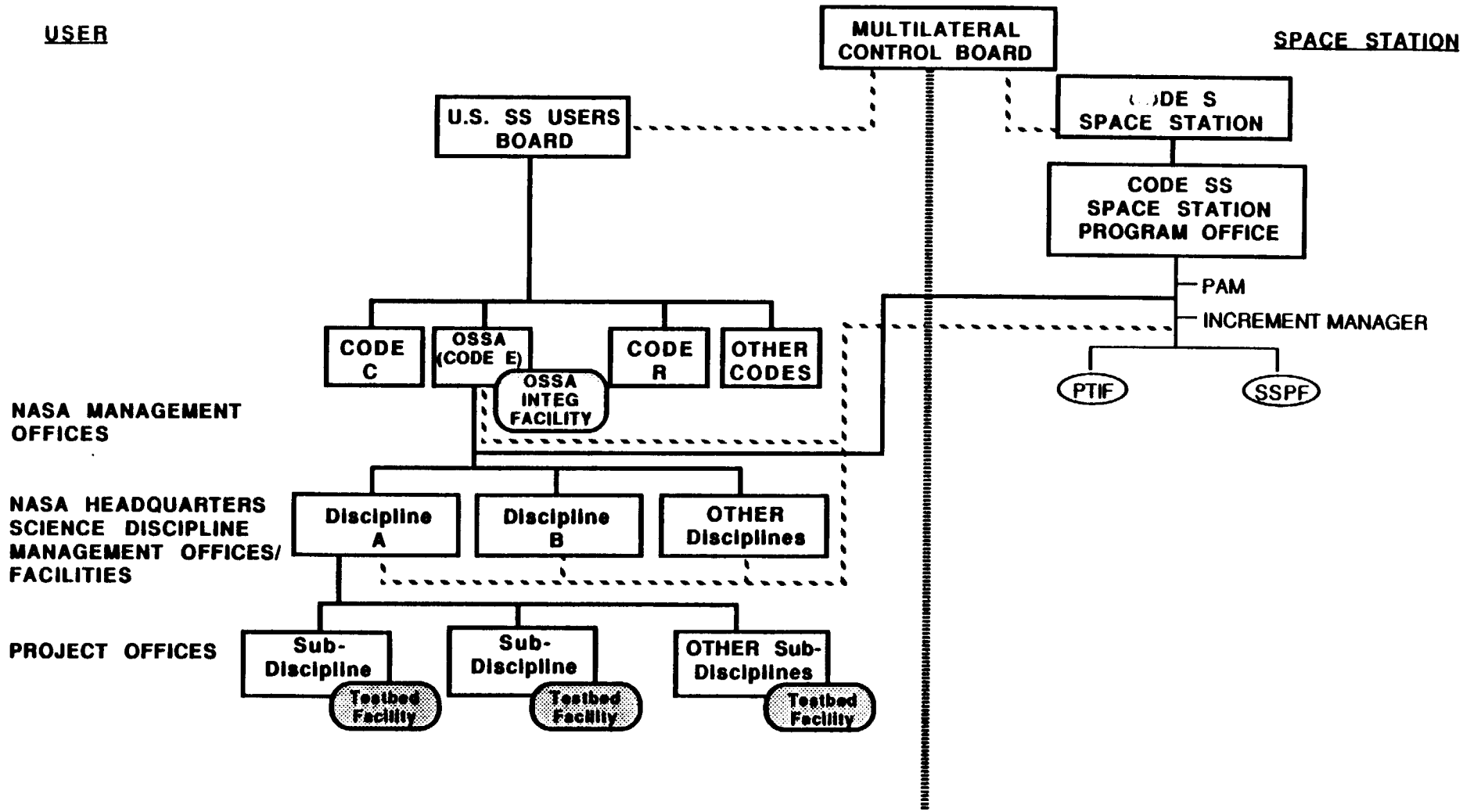
OSSA Integration Management Office/Facility

- Acts as single point advocacy for OSSA payloads with Space Station and U.S. User Board
- Manages/supports OSSA facility at a designated field installation
- Manages science activities; selects experiments for OSSA payloads
- Performs analytical integration activities and provides facilities and personnel for rack integration activities on OSSA payloads
- NOTE: Responsibility for hardware rack-to-rack checkout between U.S. Users shifts from user to Space Station. Only OSSA hardware can be assessed for compatibility
- OPTION: Other user codes can use OSSA integration facilities to reduce the number of facilities required
- Manages, schedules and coordinates OSSA training activities (conducts OSSA integrated training activities)
- Provides cadre of ground support personnel to support POIC during real-time operations

DISCIPLINE MANAGEMENT OFFICE

- Same responsibilities as previous concept except analytical integration and training activities support is provided to OSSA

OSSA USER INTEGRATION MANAGEMENT FACILITY CONCEPT



Concept focuses on a centralized user facility for OSSA. This facility accommodates rack level hardware integration and integrated training activities for OSSA science payloads prior to final Space Station interface checkout at launch site. This facility could be a S&T Center recommended by SSOFT.

Figure 3 - 5

Subdiscipline/Testbed Facilities

- Same as previous concept (experiment development)

This concept emphasizes a single point advocacy with Space Station for OSSA payloads. Total User payload compatibility, if performed, would rely on the Space Station organization and facilities. Hardware flow and pros and cons for this concept are identified in Figure 3-6 and Table 3.3, respectively.

3.5 DISCIPLINE USER SUPPORT TO SPACE STATION INTEGRATION CONCEPT

The Discipline User Support to the Space Station Integration Concept focuses on OSSA payload rack integration functions (hardware, training) being performed at S&T centers and real-time operations at Discipline Operations Centers, reference Figure 3-7. These facilities are managed and controlled by NASA science discipline organizations (i.e., Life Sciences, Astrophysics, etc). Resource allocations are distributed by the U.S. SS User Board, but managed by discipline organizations. Basic assumptions for this concept include the following.

- OSSA allocates complete racks to each of its science disciplines (i.e., Life Sciences, Astrophysics, Microgravity, Earth Science, Solar System Exploration).
- Each science discipline integrates to the rack level.
- Even though OSSA does not have an integration facility, it has an implementing organization which performs analyses, determines the need for and use of generic laboratory equipment among its discipline users, and resolves issues/conflicts.
- Space Station has an organization which performs payload integration analyses for the total module.
- The discipline facilities accommodate all subdiscipline hardware integration and training activities.
- The OSSA science discipline facilities are module interface simulators (MIS) which can be used for both hardware verification and training; therefore, rack to module interfaces must be flight-like. In addition, software simulate Space Station software for data verification.

Roles and responsibilities for the different management levels within this concept are:

MULTILATERAL CONTROL BOARD

- Same as previous concepts.

U.S. SS USERS BOARD

- Same as previous concepts.

OSSA MANAGEMENT OFFICE

- Same responsibilities for planning and management as previous concepts.
- Continues to perform/provide analytical integration for OSSA payloads.
- Responsible for interdiscipline hardware rack checkout and integrated training shifts from user to Space Station.

OSSA USER INTEGRATION MANAGEMENT FACILITY HARDWARE FLOW

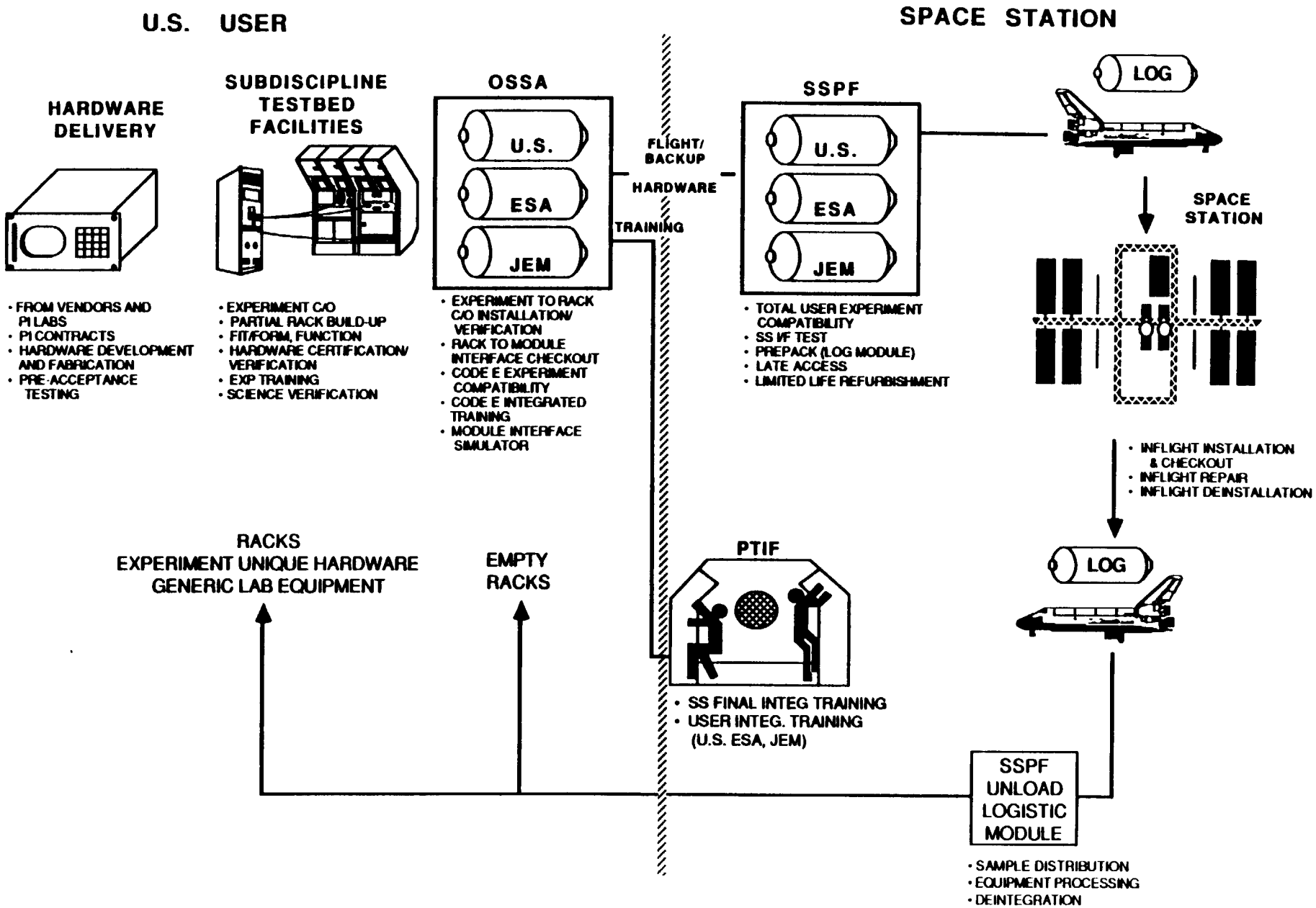


Figure 3-6

PROS

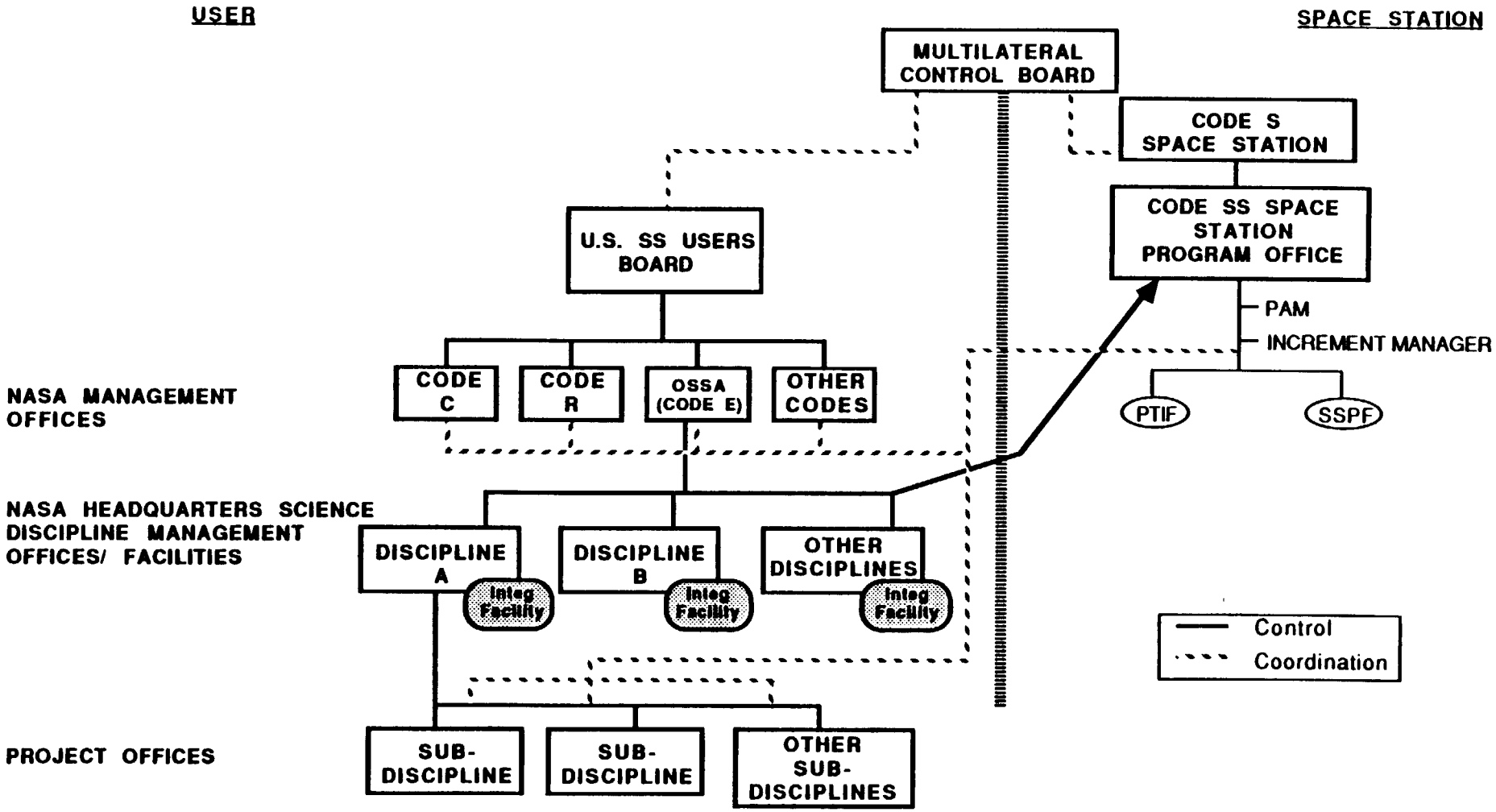
- Allows single point advocacy for OSSA users for resource allocation and science requirements definition.
- Provides capability for OSSA users to verify OSSA payload compatibility prior to interface checkout by Space Station at the launch site.
- Allows capability for payload crew to perform integrated training on OSSA payloads.
- OSSA users do not have to rely on Space Station facilities to support OSSA integration/verification and training activities.
- Schedules for use of facility are controlled by OSSA.

CONS

- Does not provide capability to verify total USER payload compatibility by user organization prior to interface checkout by Space Station at the launch site.
- If total payload compatibility is to be performed, it must rely on Space Station organization facilities and schedules.
- Does not provide capability to support on-orbit replanning for total payload by the USER.
- Does not allow capability for USER to conduct integrated training on total payload prior to Space Station integration activities.

Table 3.3 OSSA User Integration Management Facility Concept-Pros/Cons

DISCIPLINE USER SUPPORT TO SPACE STATION INTEGRATION MANAGEMENT CONCEPT



Concept focuses on rack integration functions being performed at discipline level facilities and relying on Space Station facilities for major rack to module integration activities. This facility could be S&T and/or Discipline Operations Center recommended by SSOTF.

Figure 3 - 7

OSSA SCIENCE DISCIPLINE INTEGRATION OFFICE/ FACILITY

- Allocates resources within the discipline
- Serves as focal point advocate for unified discipline interests
- Provides training facility for discipline, experiment, and generic training
- Provides for partial rack-to-module interface checkout
- Provides for partial rack-to-rack compatibility testing (hardware and software)
- Determines discipline integration and generic hardware/laboratory equipment requirements
- Performs discipline science verification and baseline data collection activities

SUBDISCIPLINE ORGANIZATION

- Develops experiments and experiment hardware requirements
- Performs training activities at discipline integration facilities

Hardware flow and pros and cons are described in Figure 3-8 and Table 3.4, respectively.

3.6 PROJECT LEVEL SUPPORT TO SPACE STATION INTEGRATION MANAGEMENT CONCEPT

This concept has science, hardware and integrated training functions being performed at S&T centers managed at subdiscipline or project organizations. The USER community has to rely on Space Station facilities and organization for total user payload compatibility assessments and verification. Reference Figure 3-9. Roles and responsibilities for the various levels of management within this concept are the same for the Multilateral Control Board, the U.S. Users Board, and OSSA Management office as in the Discipline User Support to Space Station Integration Concept. In addition, the OSSA Science Discipline Offices are also responsible for

- Resource allocation to subdiscipline offices.
- Coordinating requirements compliance and compatibility for discipline payload elements.
- Determining integration and generic laboratory equipment requirements for discipline.

Subdiscipline Office/Facilities functions include performing:

- Experiment and experiment hardware development.
- Experiment training.
- Baseline data collection.
- Partial rack build-up and checkout.
- PI contract monitoring.

Hardware flow and pros and cons for concept are described in Figure 3-10 and Table 3.5, respectively.

3.7 DISTRIBUTED INTEGRATION MANAGEMENT FACILITY CONCEPT

The Distributed Integration Facility Concept recommends an integration organization and facility at each level of management (discipline level, OSSA level and U.S. payload level) (reference Figure 3-11). Experiment checkout and training activities are conducted in

DISCIPLINE USER SUPPORT TO SS INTEGRATION MANAGEMENT HARDWARE FLOW

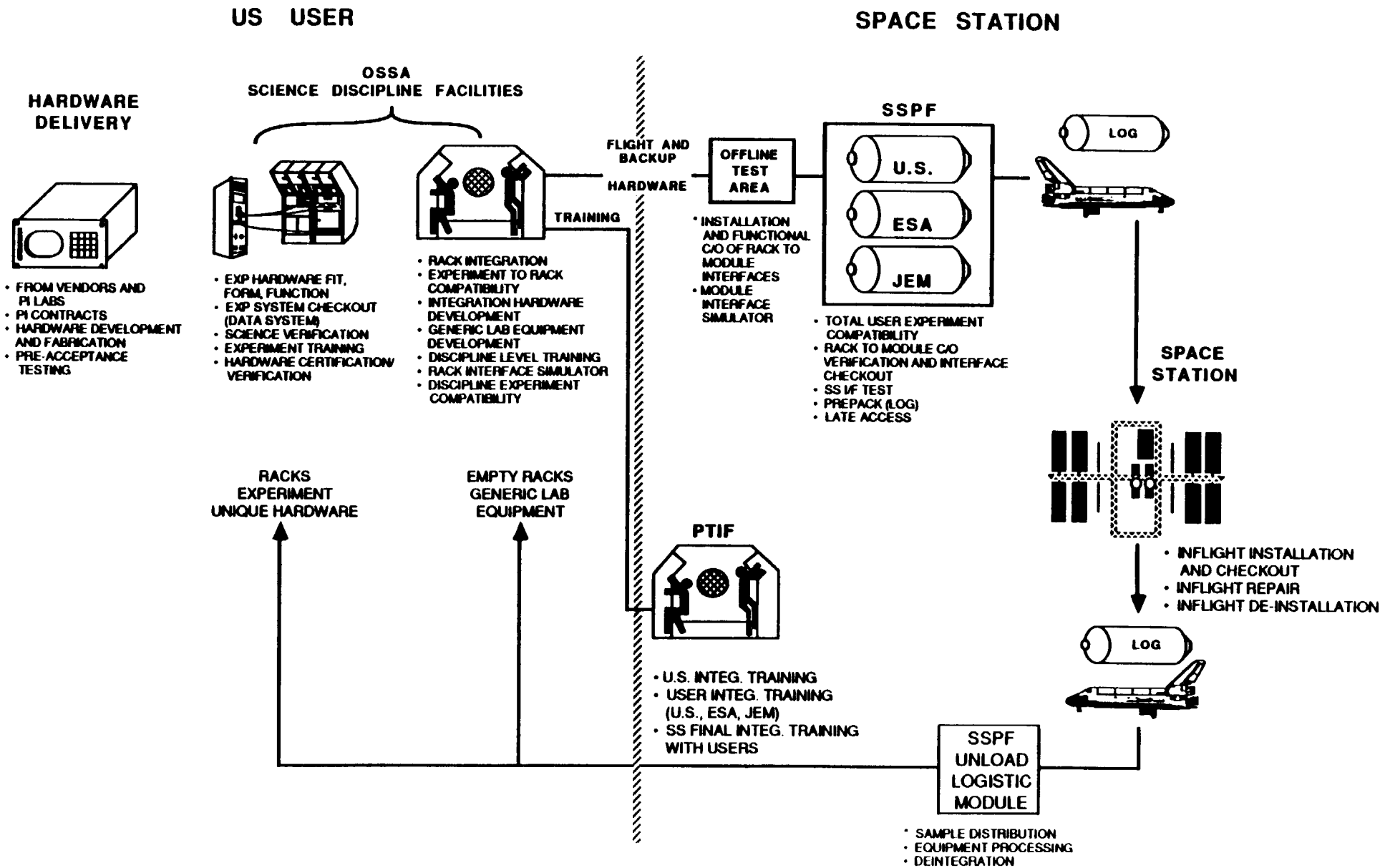


Figure 3-8

PROS

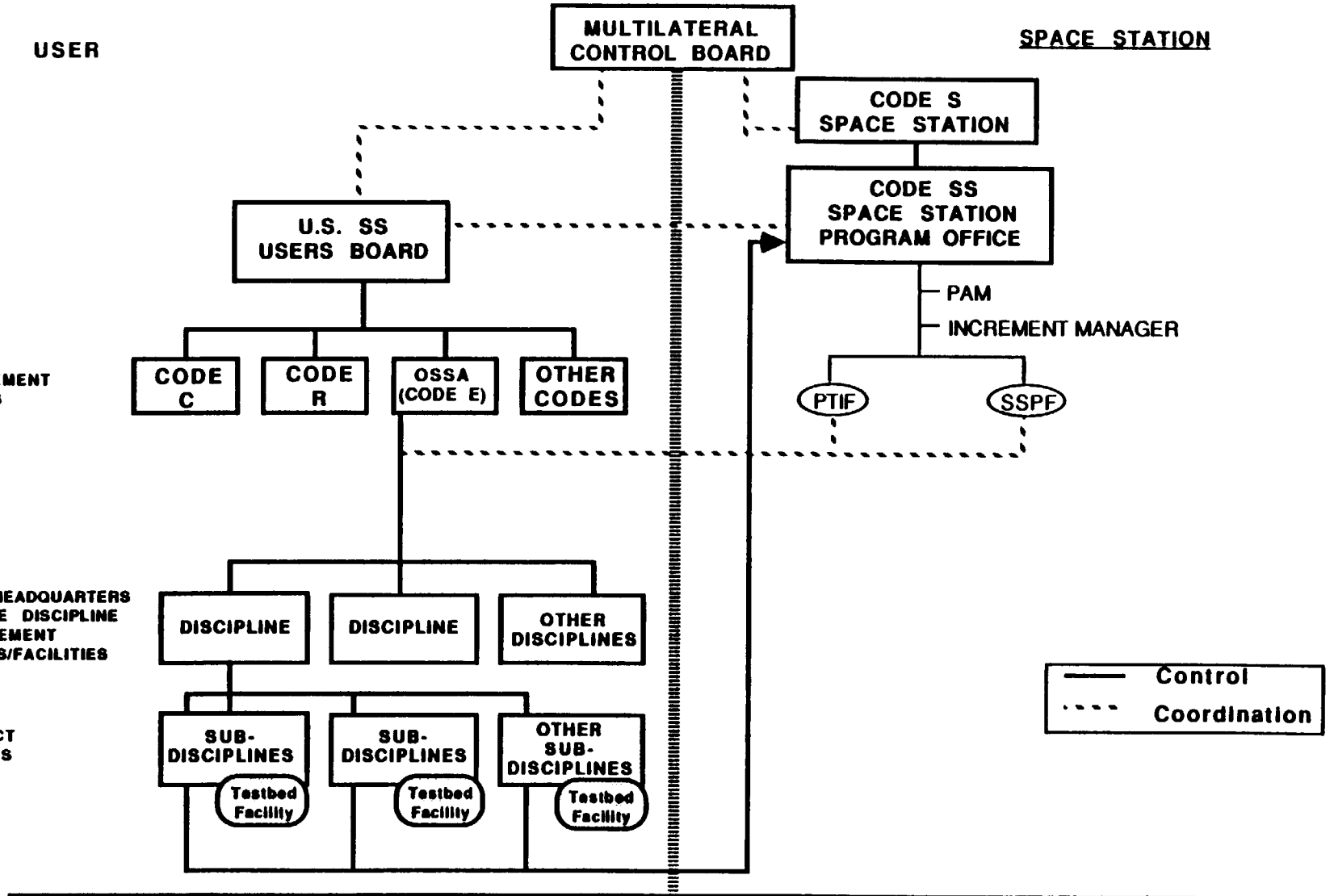
- Discipline solves rack integration and training descrepancies before integration with whole module
  - Facility is available for hardware test and checkout
  - Facility is availabe for generic discipline training
  - Facility can better accommodate training new crew members in discipline
- Allows capability for rack level integration and training activites for OSSA users before integration with Space Station.
- Integration at discipline level shortens time from development to ship to launch site; reduces number of levels for payload development and integration activities.

CONS

- Discipline office serves as focal point advocate for individual Science discipline interests on Space Station.
- Does not provide capability to verify total USER, U.S. and/or OSSA payload compatibility by user organizations prior to interface checkout by Space Station.
- Does not provide capability to support on-orbit replanning for total payload by the USER community or OSSA users.
- Does not allow capability for the USER community and/or OSSA to conduct integrated training on total paylaod.
- Will be more costly for each discipline to have its own integration facility and organization.

Table 3.4 Discipline User Support to Space Station Integration Management Concept-Pros/Cons

PROJECT LEVEL SUPPORT TO SPACE STATION INTEGRATION MANAGEMENT CONCEPT



Concept focuses on integration functions being performed at the experiment level at the S&T Facilities and relying on Space Station facilities for rack integration and rack to module integration/verification.

Figure 3 - 9

PROJECT LEVEL SUPPORT TO SS INTEGRATION MANAGEMENT HARDWARE FLOW

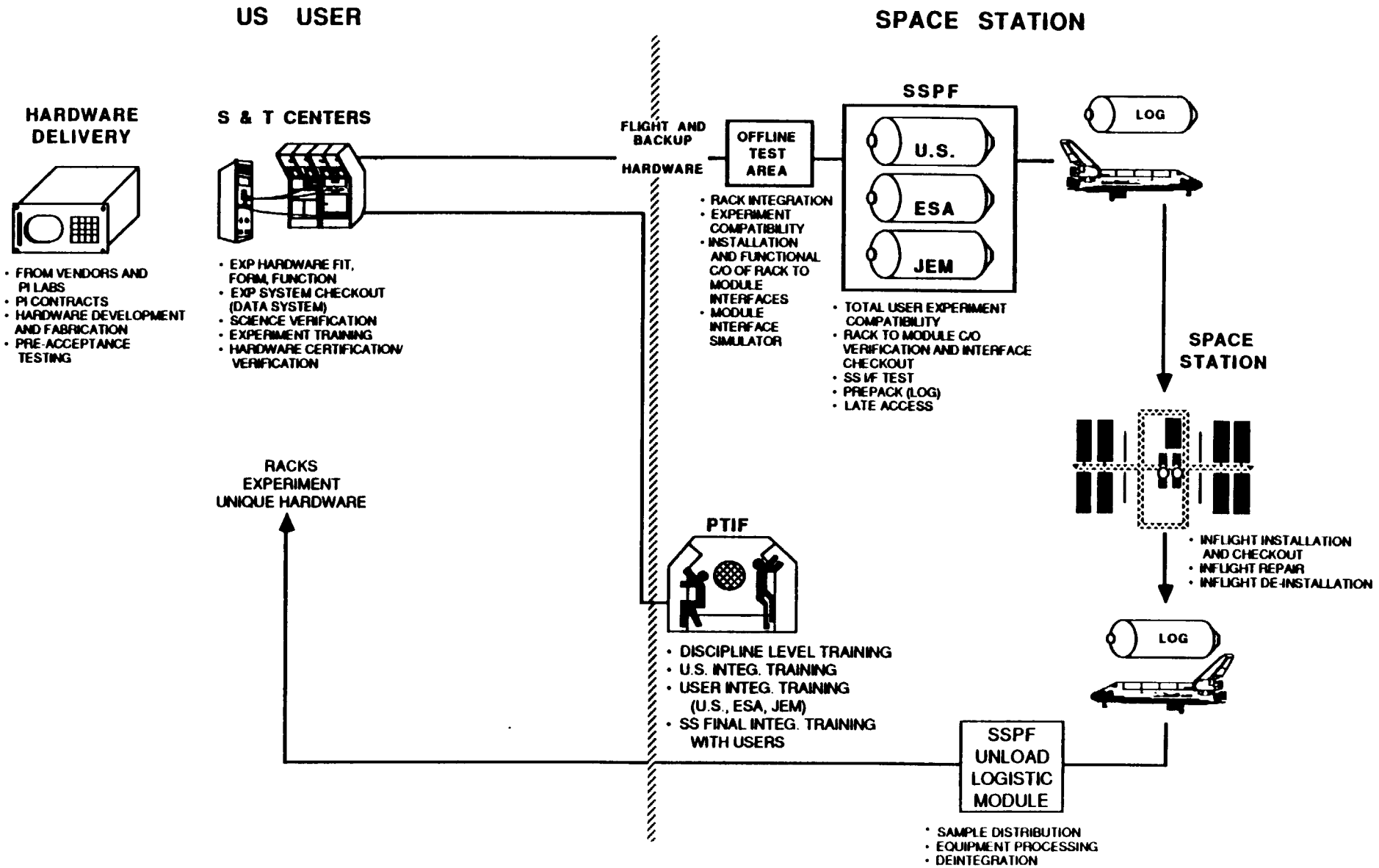


Figure 3-10

PROS

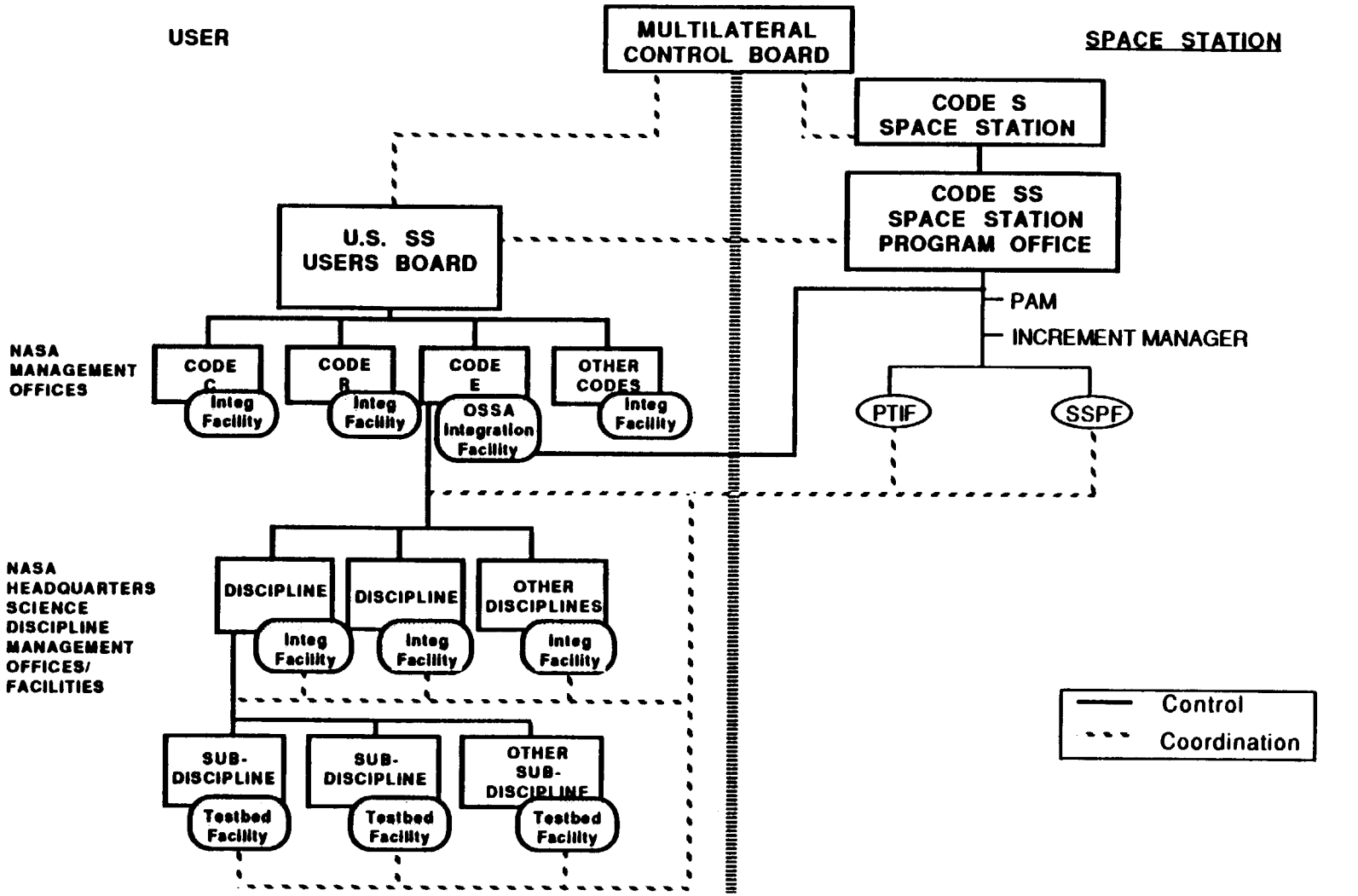
- Provides direct interface with Space Station for indiviudal Station Science principle investigators
- Shortens time from hardware development to integration with Station

CONS

- Does not provide capability to collectively verify user payloads at any level prior to final interface checkout by Space Station at the launch site.
- If total payload compatibility is to be performed; must rely on Space Station organization, facilities and schedules to perform the following activities with little time to correct incompatibilities
  - Integrated Training Activities
  - Payload Compatibility Verification
  - Hardware Integration beyond experiment level
- Increases incompatibility risk between payload elements
- Requirements for facilities and organizations at each level are prohibitively costly
- Increases probability of on-orbit failures

Table 3.5 Project Level Support to Space Station Integration Management Concept-Pros/Cons

DISTRIBUTED INTEGRATION MANAGEMENT FACILITY CONCEPT



Concept focuses on integration functions and responsibilities being distributed at all user discipline and subdiscipline facilities with user payload integration at a Code facility. Total user payload integration relies on Space Station organizations and facilities.

Figure 3 - 11

testbed facilities managed by subdiscipline organizations. Discipline level integration activities are conducted in discipline integration facilities managed by OSSA science organizations.

OSSA payload integration activities are conducted in an OSSA Integration Facility managed by an OSSA integration organization. Overall user payload compatibility, if performed, relies on Space Station organizations and facilities.

A detailed evaluation of this concept was not performed because the study team felt that the concept was unrealistic from a cost viewpoint because of the requirement for numerous facilities at the different management levels.

3.8 CONCEPT SELECTION CRITERIA

After an evaluation of the six concepts by the team, none of the spectrum of alternatives completely described the optimum and most cost efficient integration management approach for user payloads. It was concluded from the preliminary analysis that a combination of all six concepts is probably the optimum integration management structure because of the varying integration activities that must be performed to insure maximum compatibility between user requirements and Space Station requirements. The different aspects of management control and implementation for resource allocation and management, science integration and management, hardware integration (physical and analytical) payload compatibility assessments and inflight operations management require different levels of management.

The study team grouped integration functions into three major areas to focus on the optimum integration management concept that will best accommodate OSSA payload requirements and activities. Areas include:

- Science planning and resource allocation/management
- OSSA User payload integration management for ground operations activities that include physical and analytical hardware integration activities, ground support and payload compatibility assessments.
- Real-time Operations Management

Table 3.7 is a matrix that depicts the results of an evaluation that determined the level of management and single point interface and control for planning and implementing the various tasks associated with each area. Pros and cons identified through initial analysis were also used during the evaluation.

The evaluation revealed that for science planning and resource allocation management, a single point interface to Station is required to assure a greater science return to the USER community. This can best be accomplished through an International Space Station User Board that represents the total User community (including internationals) with Station. Science requirements definitions and integration that determines USER resource allocation are provided by User Organizations within each country. For hardware integration and operation management, the single point interface for OSSA with Station should be through an OSSA Integration Organization that is responsible for planning and implementing user requirements, payload compatibility assessment activities, hardware integration, operations management, resource management, data management, on-orbit replanning, etc.

Other factors considered during the evaluation include:

SCIENCE PLANNING AND RESOURCE ALLOCATION

Task \ Management Level	International SS Users Board	U.S. Users Board	OSSA NASA Hdqtrs		Subdiscipline (Project)
			Integration Organization	Science Discipline	
. Single Point Advocacy For User Requirements With Station	X				
. Resource Allocation		X (U. S. Users)		X (U. S. Users)	
. Resource Bartering Among Partners	X				
. Science Requirements Integration	X (All Users)	X (U. S.)		X (OSSA)	
. Science Requirements Definition and Development					X
. Resource Allocation Management			X		
OSSA Payload Integration and Operations Management					
• Interface With Station			X		
• OSSA Payload Compatability Assessments (Systems Analysis)			X		
• Flight Increment Planning			X		
• S&T Center Certification & Management			X		
• Hardware Integration/ Certification at S&T			X		
• Data Management (Real-Time Operations)			X		
- Acquisition				X	
- Distribution				X	
- Archival				X	
• Training (Flight Crew)					
- Experiment/ Discipline				X	
- OSSA Integrated			X		
• Training (Ground Crew)					
- PI's				X	X
- POIC Cadre Personnel			X		
• Operations Management					
- PI's				X	X
- POIC Cadre			X		

Table 3.7 Evaluation Matrix

- Time required to develop payload (experiment development to ship/launch)
- Number, type and level of management for facilities to accomplish these activities.
- Location of facilities to perform integration and certification activities.
- Cost of facilities and hardware required to support the concept
- International concerns regarding science coordination and use of the crew to perform inflight operations.

From this evaluation, the study team developed a recommended Integration Management Concept for OSSA payloads. The following section describes this concept in detail.

Recommended OSSA Space Station USER Integration Management Concept Section 4.0

4.0 RECOMMENDED OSSA SPACE STATION USER INTEGRATION MANAGEMENT CONCEPT

4.1 PROPOSED CONCEPT OVERVIEW

Figure 4-1 depicts the recommended integration management concept defined by the study team to accomplish OSSA science payloads integration management planning and control for the Space Station Program. OSSA will interface with the Space Station organization through the framework recommended by the SSOTF; i.e., the Multilateral Control Board (MCB). The study team also recommends that the preferred option put forth in the SSSOMC study (reference 6) should be utilized and implemented for Science management. The option recommends that the user community form an International Space Station Users' Board with representatives from all user countries. This board serves as a united entity when representing the USER community. Its primary functions are to:

- Establish long term user goals and objectives
- Integrate user requirements
- Support Space Station strategic planning with a five year user requirements plan
- Provide recommendation to Space Station crew selection process
- Support Space Station tactical planning with a two year user requirements plan
- Barter resources among international users → who has final say?

This board is equivalent to the Multinational USER Control Board discussed in the Multinational Payload Integration Management Facility Concept, Section 3.2. The study team feels that a greater science return can be obtained for the USER community as a whole by combining resources with international partners and establishing science goals. The International USER's Board controlled and managed by the USER community is an ideal management framework for accomplishing this objective.

The U.S. Space Station User's Board:

- Develops the U.S. two year tactical operations plan and allocate resources to U.S. USER organizations.
- Performs U.S. USER coordination and compatibility
- Selects U.S. science and experiments for Space Station participation
- Provides inputs to crew selection process

Within OSSA, science planning and management is the responsibility of the various discipline organizations working together through OSSA's Space Science Users Working Group (SSUWG) (see section 4.2). The SSUWG also allocates OSSA's portion of Space Station resources to the various disciplines (see section 4.3) based on science requirements provided by OSSA science discipline and subdiscipline organizations in support of 5 year strategic planning.

The OSSA User Integration Office has responsibility for performing OSSA ground operations for payload compatibility assessments and managing resource utilization according to the allotments established by OSSA SSUWG (see section 4.3). This office is responsible for payload integration management which includes:

- Management of science payload integration

OSSA SPACE STATION INTEGRATION MANAGEMENT CONCEPT

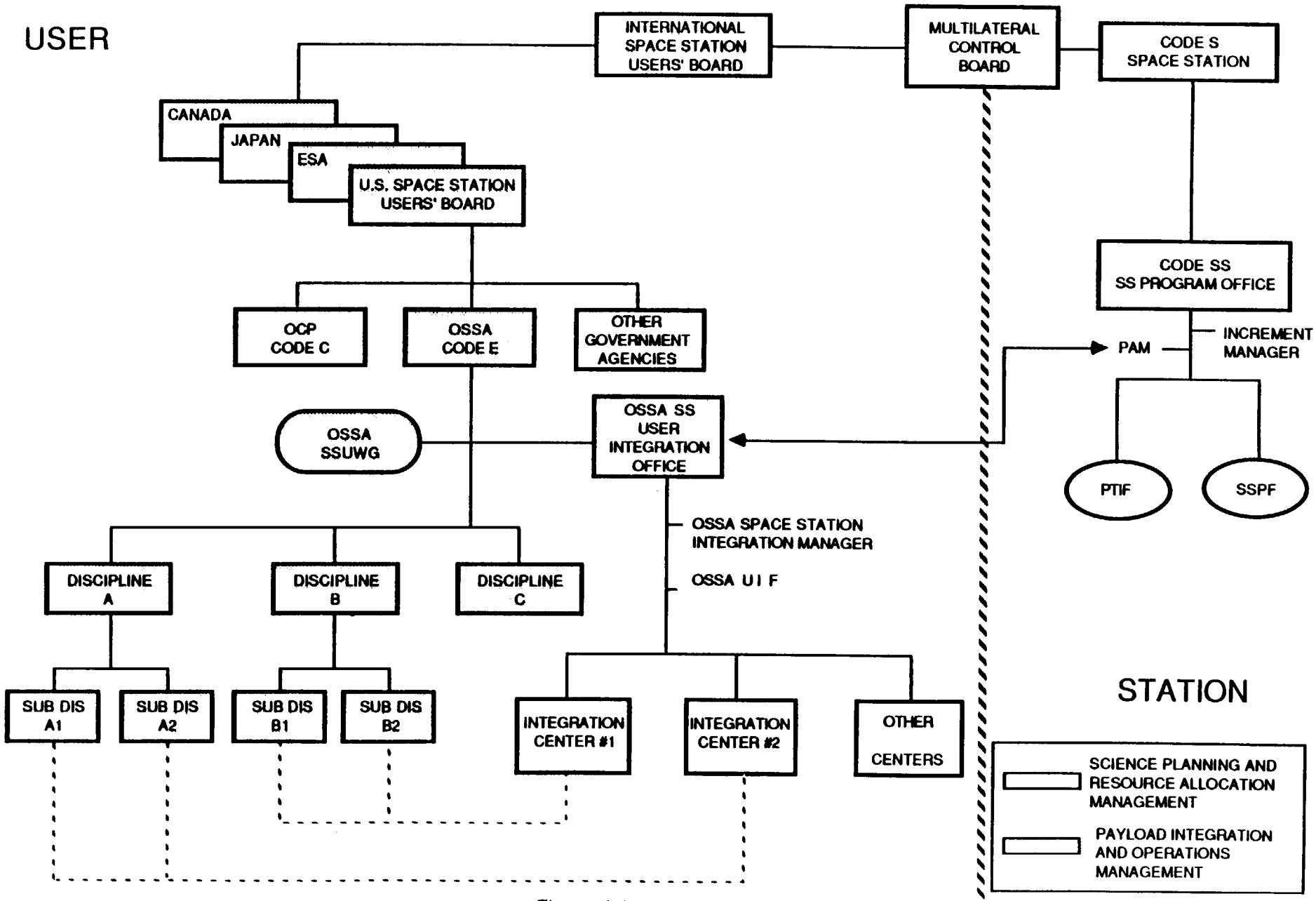


Figure 4-1

- Ground operations activities (physical and analytical hardware integration and integrated logistics management) (section 4.6)
- Flight increment design of user payload
- Integrated training
- Real-time operations to include data acquisition and distribution and archival (see section 4.4)

This office also provides the formal interface for OSSA to the Space Station Program Office for OSSA during the Payload Integration Process (PIP).

The study team recommends that an OSSA User Integration Facility (UIF) should be created in conjunction with, but not necessarily co-located with, the Integration Office that is used for hardware module integration, experiment compatibility, integrated training and real-time flight support activities. The study [illegible] that Science and Technology Centers should be designated, possibly, [illegible] centers to perform rack level hardware integration for OSSA [illegible].

Each OSSA Discipline Office assigns staff as required to reside in OSSA's Space Station User Integration office to serve as liaison between science planning and integration planning activities. It is the responsibility of the discipline manager to keep the discipline offices informed of relevant changes in policy, procedure and implementation practice which may affect payload/flight increment planning in each discipline and to be the primary discipline interface with the OSSA SS Integration Manager.

4.2 SCIENCE PLANNING AND MANAGEMENT APPROACH

The primary objectives of Space Station science management approach for users involved in the Space Station program should be to:

- Optimize science return from each investigation
- Minimize redundancy in investigations
- Maximize efficient use of Space Station and launch/landing vehicles and ground resources
- Modularize space research hardware for integration ease
- Identify multiple discipline suppport equipment
- Facilitate ease of integration at user facilities and Space Station launch facilities

Figure 4-2 depicts OSSA science management structure recommended to promote implementation of these objectives.

It is recommended that OSSA form an OSSA Space Science USERS Working Group (SSUWG) to coordinate discipline science inputs to the U.S. SSUB. The OSSA SSUWG is responsible for developing OSSA's 5 year strategic science plan that defines OSSA's long range integrated science program requirements and a 2 year tactical operations and integration plan that defines how these programs are implemented.

These plans are the basis for planning resource requirements and are forwarded through the SSUB and ISSUB for evaluation as inputs to the Multilateral Control Board for input to the five-year Consolidated Utilization Plan (CUP) and the [illegible]ear Tactical Operations Plan (TOP). In turn, these plans are used by OSSA to allocate Space Station resources to the OSSA Discipline Offices.

OSSA SPACE STATION SCIENCE MANAGEMENT APPROACH

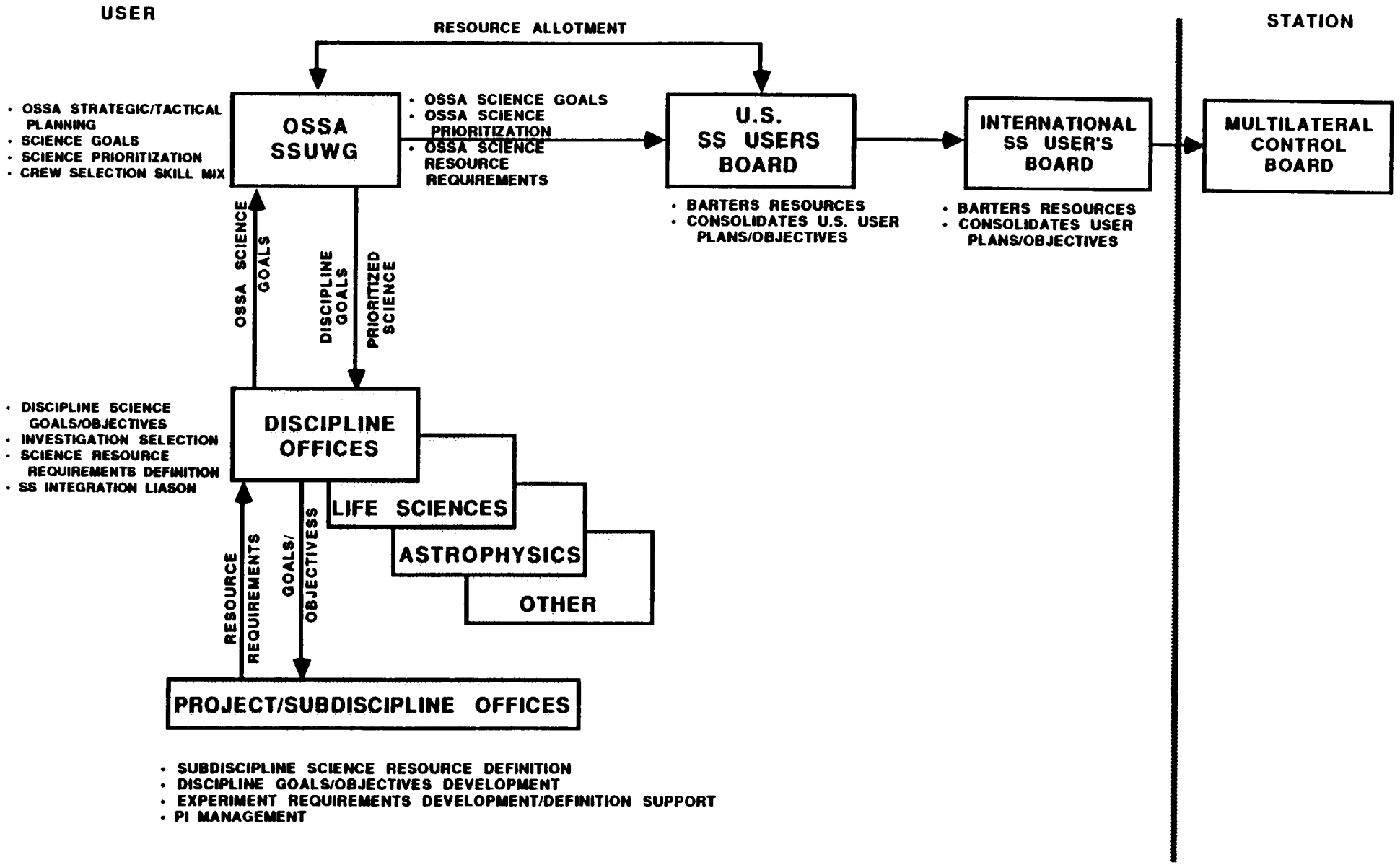


Figure 4-2

It is recommended that OSSA Discipline Scientists from each division, or their designated representatives, participate in the SSUWG. In addition to the Discipline Scientists, a Discipline Engineer from each division and liaison from OSSA Space Station USER Integration Office should also participate in the OSSA SSUWG. These discipline representatives are cognizant of mission needs and flight peculiar constraints for each of their subdisciplines. The SSUWG is responsible for developing a cohesive position for meeting OSSA Space Station flight goals and user science/engineering requirements which can be presented by the SSUWG spokesperson to the SSUB. The strategy is developed based on information and planning that occurred through participation in Discipline Working Groups. Each Discipline Science representative to the SSUWG is responsible for bringing the discipline position to the SSUWG.

Discipline science goals, objectives and science resource requirements provided by inputs from subdiscipline organizations are used to support SSUWG planning activities.

4.2.1 Science Prioritization

It is recommended that each discipline should be responsible for providing discipline science priorities to the SSUWG. The disciplines form Discipline Working Groups (DWG) whose membership is composed of representatives from NASA headquarters and field centers, academia and industry. Existing discipline working groups or advisory panels may perform this function. The primary functions of the DWG is to (1) determine the science objectives of the Space Station Program for that discipline, (2) suggest reference experiment scenarios which would meet specific science objectives, (3) develop suggested payload scenarios in order of implementation priority for that discipline, (4) define the science resources required to support each scenario, including potential hardware, software, sample requirements and crew interface requirements, and (5) through representation on the International SS User's Board determine if these U.S. science objectives overlap or conflict with those of other Space Station users.

When final resource allocation is made, the DWG develops a final payload scenario. The experiments in this scenario are sent to the SSUWG with a recommendation for flight selection and final development.

4.2.2. Science Integration

Science integration activities, in contrast to operations integration activities, are directed toward meeting the established NASA science goals; maintaining the science integrity of individual experiments, from rack through mission integration on board the Space Station; and minimizing the adverse impacts of concurrent investigation operations on the collection of critical data.

In the recommended concept, science integration begins with payload scenario development by the DWG and is an iterative process which uses inputs provided by subdiscipline organizations developing the investigations. Integration of an initial payload scenario is highly dependent on the final resource allocation for a given flight opportunity. The subdiscipline organization, upon receiving the selected sets of experiments from a specific AO from the HQ Discipline Offices, develops reference payload scenarios from these AO subsets, selects from them a subset of investigations which are most feasible with the resources allocated, and forwards these recommendations to the DWG. Subsets may be a single investigation or multiple investigations, based on project critical analysis of resource requirements and probable implementation support requirements.

The payload experiments finally selected by OSSA for flight are developed and implemented by the subdiscipline organization. The OSSA Space Station User Integration Office begins the payload integration process with Space Station and provides overall management for all payload activities and interfaces with the Station. Science integration at the subdiscipline level includes ascertaining compatibility of science operations at the experiment level; i.e., real-time operations interference and compatibility of human subject measurements. It also includes following all integration activities that occur after the experiment leaves the subdiscipline organization.

4.3 RESOURCE ALLOCATION AND MANAGEMENT APPROACH

Resource allocation includes all of the tasks for determining how the Station's user resources will be distributed among different user groups (reference Figure 4-3).

The SSOTF recommended that the MCB divide among the Space Station partners the total station resources [illegible] the [illegible] the Station and crew. International memorandums of understanding (MOU) provide the MCB with projections of Station resources over a 5 year period. The MCB reviews this projection in light of MOU agreements and notifies partners of resources available to each. Once resources are allocated, each partner is free to select and operate within the resource envelopes allocated.

It is recommended that the U.S. Users Board allocate blocks of resources to the U.S. User NASA offices and that these offices develop a method of allocating resources within their respective responsibility.

After Station capabilities are identified and resources are allocated by the MCB to each partner's SSUBs, OSSA's SSUWG works with the U.S. SSUB to develop a 5 year Space Station Resource Utilization Plan. This 5 year plan is used as a basis for:

- Preliminary Science Selection
- Initial Compatibility Assessments
- Program Definition Activities
- Requirements Definition
- Flight Increment Assignments
- Flight Increment Design Planning Acitivities

It is recommended that the SSUWG allocate resources to OSSA Science Discipline organizations based on the following:

- OSSA's overall program goals and objectives
- Science Prioritization
- Payload/Station Compatibility Assessments (Module Location, Volume, Weight, etc.)
- Cost/Budget

Resource allocations for OSSA are determined by science requirements provided by the recommended science management hierachy discussed in previous sections. Once resources are allocated, it is recommended that OSSA's Space Station User Integration Office verify compliance and manage actual resource utilization.

SPACE STATION RESOURCE ALLOCATION PROCESS

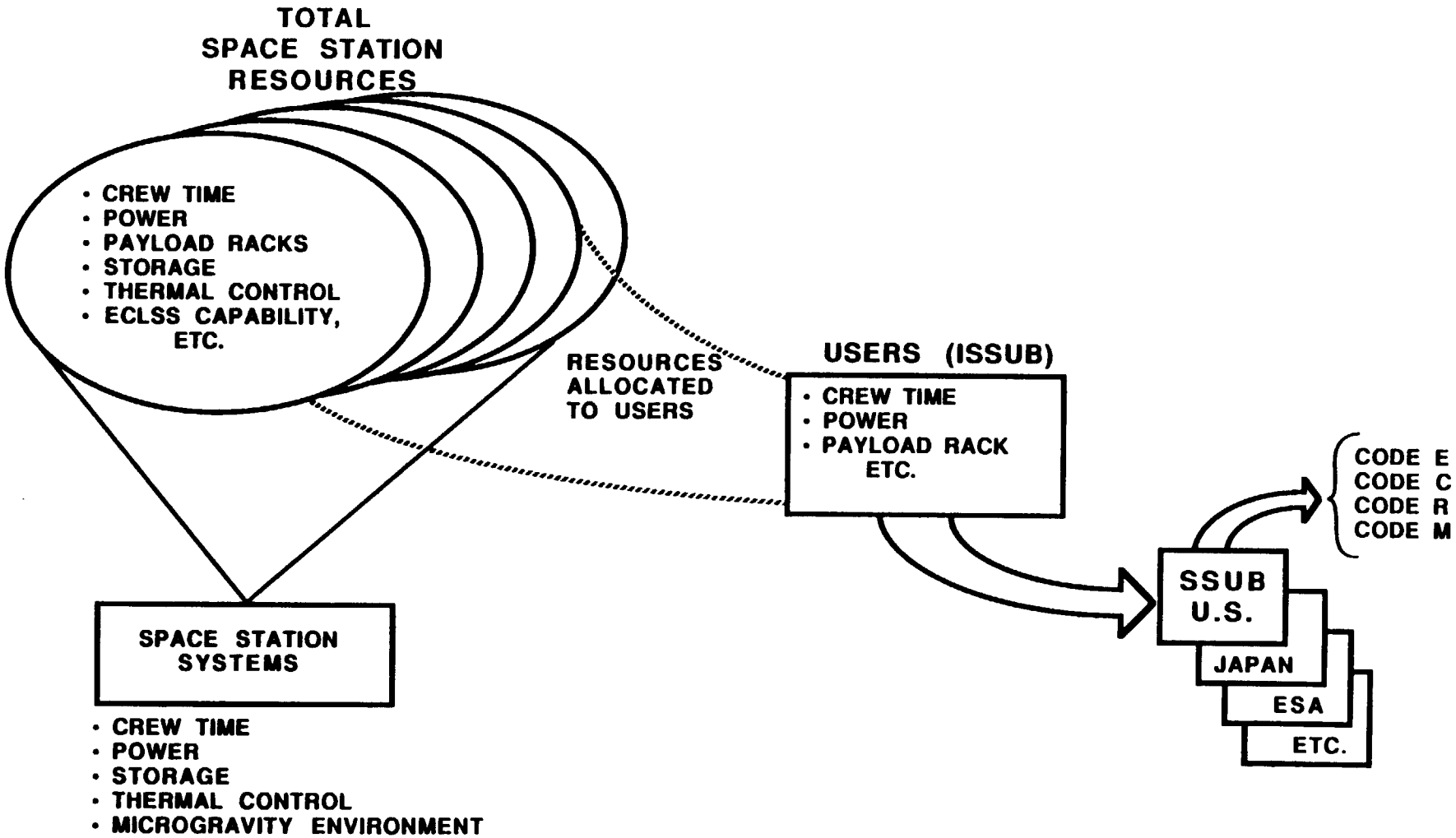


Figure 4-3

Resources allocated to the Discipline offices should be in blocks. If practical, complete SS racks be allocated to discipline organizations. [redacted]

4.4 GROUND OPERATIONS MANAGEMENT APPROACH

OSSA has reponsibility for planning and managing five major ground operations areas: hardware/software integration and checkout, payload and ground support crew training, data acquisition and distribution, integrated logistics, and real-time station payload operations. The following section describes management approaches for the planning and control of these activities.

4.4.1 Flight Hardware/Software Integration and Checkout Management Approach

Figure 4-4 shows the various levels for planning and controlling hardware/software development integration and certification. Figure 4-5 shows an OSSA hardware integration flow for the Space Station program. It is recommended that User science hardware development, integration and certification activities occur during six different phases:

1) Science hardware development and checkout at Experiment Development centers.
2) Science hardware to rack integration and checkout at S&T Centers.
3) OSSA rack to module interface checkout at OSSA S&T UIF.
4) Final rack to carrier integration and checkout at launch site.
5) Carrier to launch vehicle integration at launch site.
6) Inflight installation and checkout by crew remotely assisted by ground support personnel.

Management of hardware integration and checkout moves from the Discipline/ Subdiscipline Office to the OSSA Space Station UIO to the Space Station Office to the POIC, depending on the phase. Prior to the first phase, the Discipline Offices are responsible for performing technology assessments and determining the standard science laboratory equipment to be developed or utilized. The Discipline Offices also determine the experiment-specific hardware to be developed or utilized. The Discipline Offices assign the development of standard and experiment-specific hardware to appropriate Subdiscipline or Experiment Development Centers at the various NASA field centers.

It is recommended that OSSA Subdiscipline offices manage the development and testing of standard and experiment-specific hardware for flight and training. The Subdicipline or Project Offices also manage the refurbishment and testing of any hardware returned from flight and planned for re-use.

The [redacted] l. The actual work may be performed by the Subdiscipline or Project Office personnel but is planned and controlled by the S&T Centers. [redacted]

The OSS[redacted]. This Office also manages experiment compatibility testing of all experiments comprising the science payload. Management of these operations allows OSSA to test its science payload thoroughly prior to interfacing with the Space Station organization and to perform integrated crew training on the total OSSA payload.

OSSA SPACE STATION INTEGRATION MANAGEMENT CONCEPT
GROUND INTEGRATION AND CHECKOUT MANAGEMENT

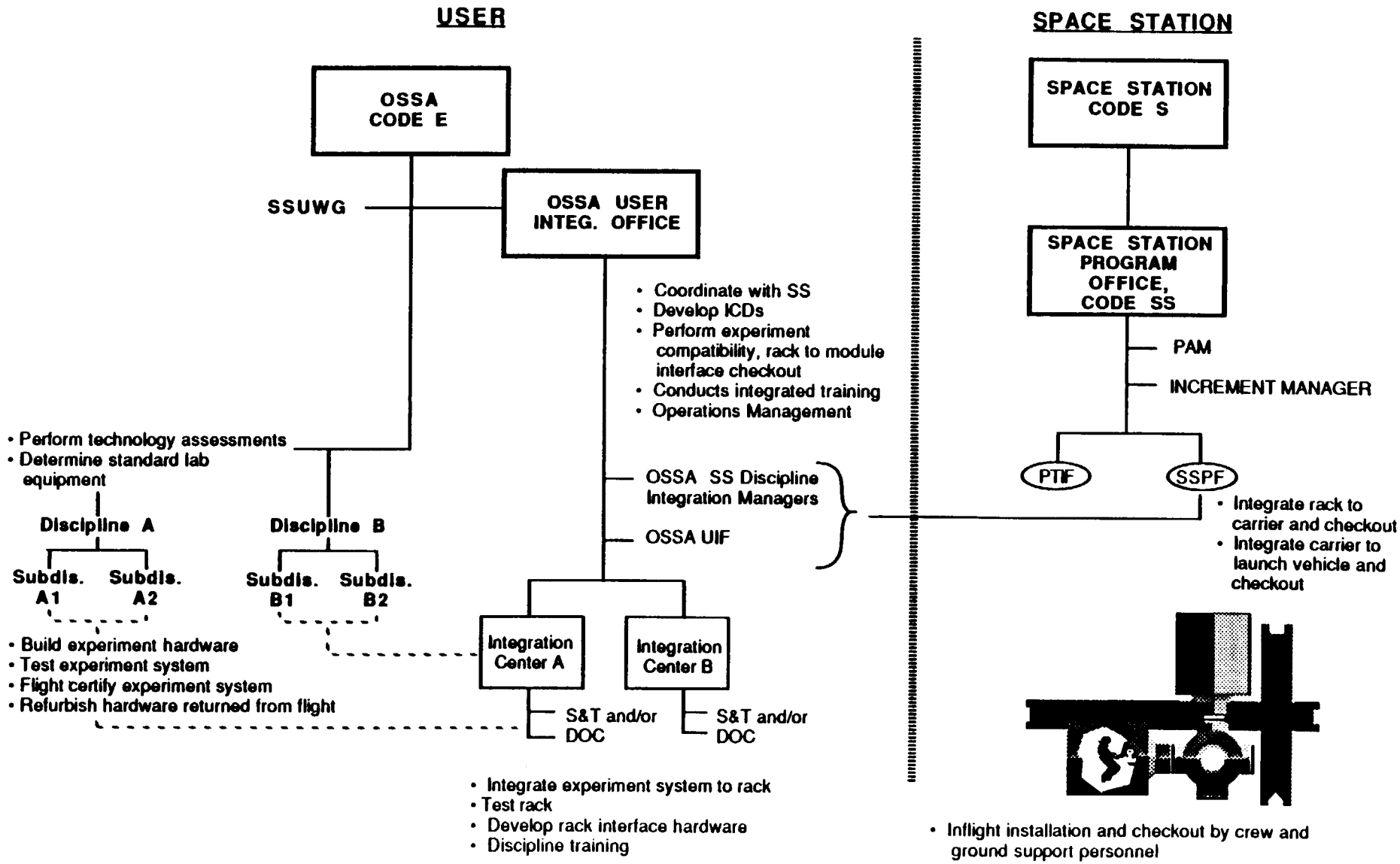


Figure 4-4

OSSA SPACE STATION HARDWARE INTEGRATION FLOW

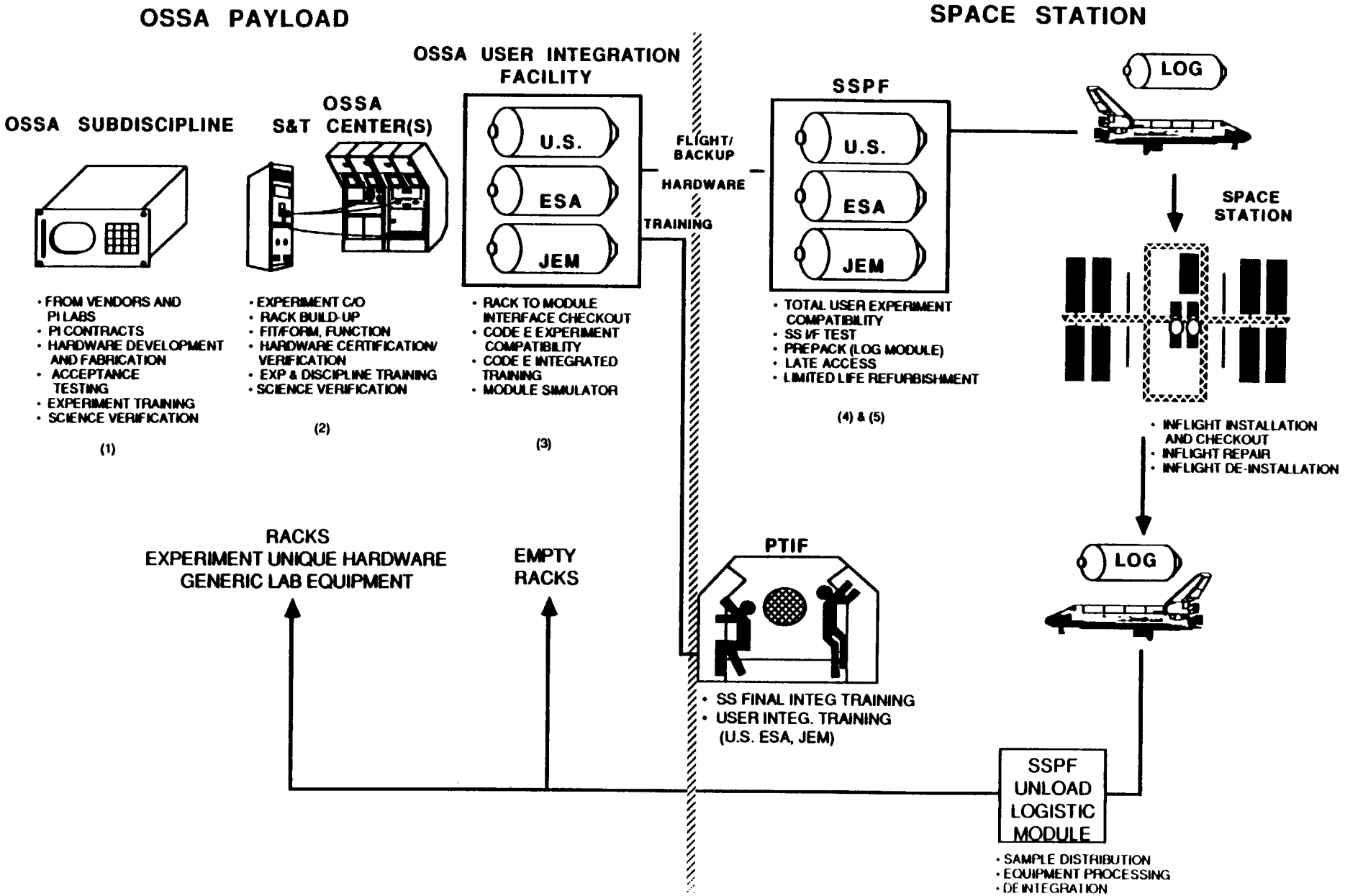


Figure 4-5

The Space Station organization has responsibility for bringing the total increment payload together and checking hardware compatibility with Space Station. This Space Station organization manages the integration and check out of the rack to the carrier and the carrier to the launch vehicle.

Following delivery of the payload hardware to the orbiting Space Station, the crew installs the equipment inflight. The equipment can be tested by the crew and/or from a remote location via commands from the ground. Inflight installation is managed by ground support personnel working through the POIC.

It is recommended that OSSA UIO develop an overall data information system that unifies individual discipline data systems and supports interfaces with the Space Station Program's Space Station Information System (SSIS) for on-orbit data requirements, the Technical Management Information System (TMIS) and NASCOM. The goal of OSSA's data information system is to facilitate multi-disciplinary teleoperations and teleanalyses through the development or adoption of standards, guidelines and capabilities for telecommunications, data management, user interfaces and operations concepts.

OSSA data system development and implementation is facilitated by user inputs from discipline and subdiscipline organizations. Data verification activities is the responsibility of the OSSA UIO. The UIO is responsible for data coordination and distribution to Discipline Operations Centers and other User Operations Facilities (UOF) during real-time operations. Discipline organizations are responsible for data archival and data distribution to PIs.

4.4.2 Training Management Approach

It is recommended that the OSSA Space Station User Integration Office have responsibility for managing payload crew and ground support personnel training (reference Figure 4-6). This training includes:

- Experiment-specific science operations training.
- Standardized discipline training such as blood draws, animal feeding, sun or Earth observations.
- Hardware installation and checkout.
- Hardware troubleshooting, repair, and/or de-integration
- OSSA science payload integrated operations
- Ground support operations.

The UIO is responsible for establishing an overall training philosophy, for developing training plans and requirements for training hardware and software, and for directing training activities. The UIO serves as an interface to the Space Station and STS organizations for crew training and to the POIC for ground support personnel training. The UIO has responsibility for final certification of crew members and ground support personnel for OSSA payload training. The UIO also manages the development of the Science Payload Flight Data File (SPFDF) and provides it to the Space Station organization for final integrated training and flight.

The Discipline S&T Integration Centers have responsibility for planning, developing, and managing standard laboratory training as part of a core curriculum of payload operations for all astronauts. The study team recommends that each discipline develop a core curriculum for routine laboratory activities such as urine voids, blood draws,

OSSA SPACE STATION INTEGRATION TRAINING MANAGEMENT CONCEPT

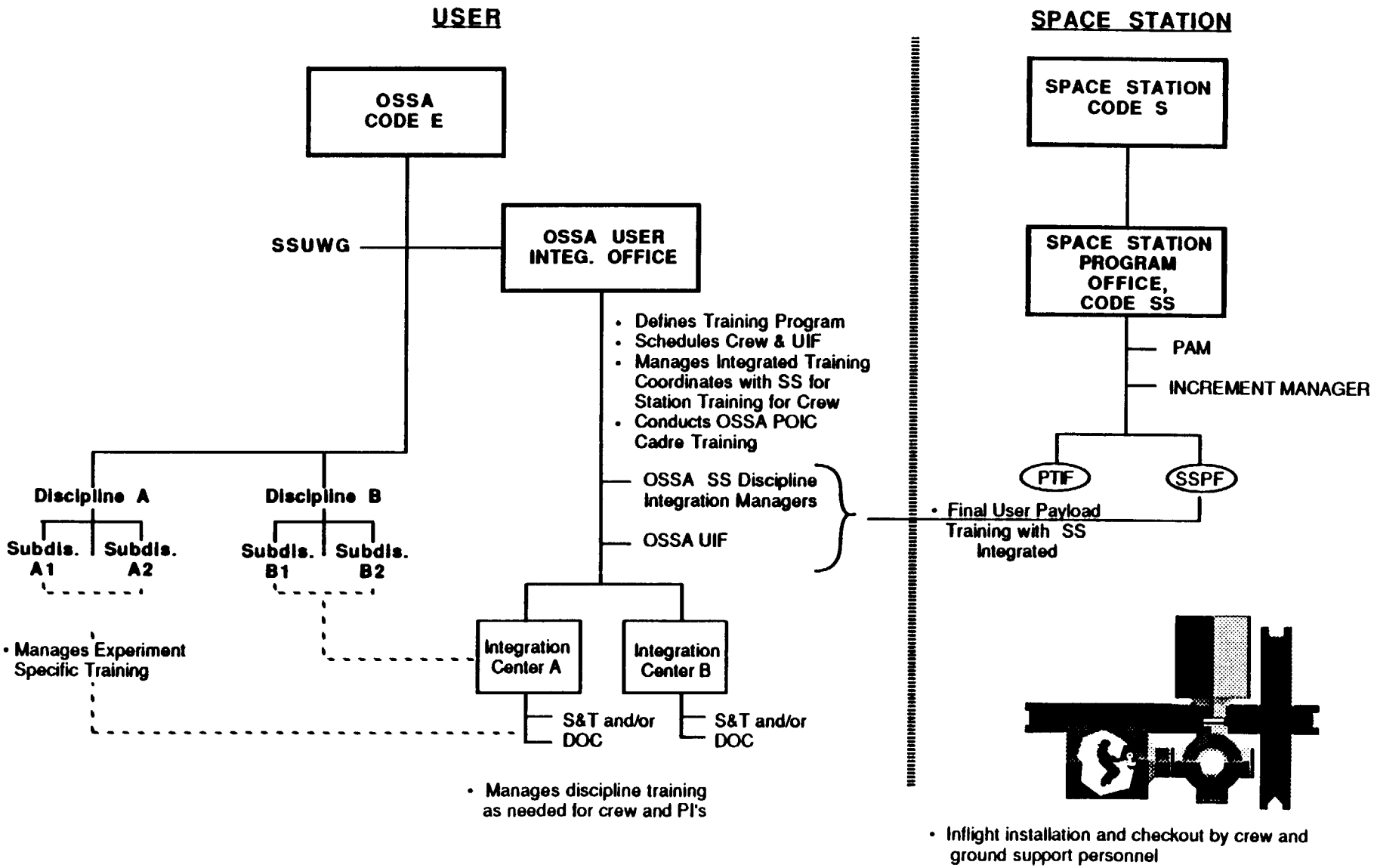


Figure 4-6

exercise, etc., and other sciences operations as identified (e.g., animal health checks, sun / Earth observations, etc.).

4.4.3 Real-time Payload Operations

The SSOTF recommends that POIC (reference Figure 4-7) be provided by the Space Station program to the User. Its function is to schedule user activities for the manned base, building on the template provided by the Space Station Support Center (SSSC). It's function is to:

1) integrate the user requirements according to user resource envelopes and available resources provided by the SSSC,
2) assist users in periodic "replanning,"
3) aid the user science/payload working groups in user conflict resolution, and
4) support distributed independent User Operations Facilities (DOCs, POCs, etc).

Thus, the on-orbit crew time and other resources available for users are managed by the POIC in cooperation with the SSSC. The functions of SSSC are normally transparent to the user community during routine payload operations.

The SSOTF recommends that the POIC be managed and controlled by Space Station because of the complexity of both SS systems and User Operations to ensure crew safety. The study team feels that User Operations and requirements would best be served if the POIC is managed and controlled by the User Community. However, to support the SSOTF recommendations, Figure 4-8 depicts a concept for a POIC structure to ensure maximum input and interface from the User Community. It is recommended that the POIC be managed by Space Station Payload Operations Director with a staff consisting of:

1) A cadre of real-time operations personnel responsible for providing payload operations control, data flow management and flight increment replanning functions.
2) User Element (U.S., Japan, etc.) Science Operations Directors (SODs) and science support personnel or Discipline Operations Representatives (DORs) charged with providing science direction and detailed conduct of their respective flight increment science operations.

The DOR teams are located in the POIC Support Rooms and/or at DOCs, and serve as single point interfaces between SODs and PIs. The DOR teams provide real time support for data acquisition and archival, system engineering support, and discipline science support. It is recommended that OSSA UIO provide training to the U.S. SOD and DOR support personnel for flight increments that are comprised primarily of OSSA user payloads.

4.5 FACILITY REQUIREMENTS

To support OSSA payload integration and operations activities, it is recommended that OSSA provide the following facilities.

- S&T Centers (SSOTF recommended) to support discipline and/or experiment development and rack integration activities. S&T Centers are certified by Space Station.

SSOTF REAL-TIME OPERATIONS CONCEPT

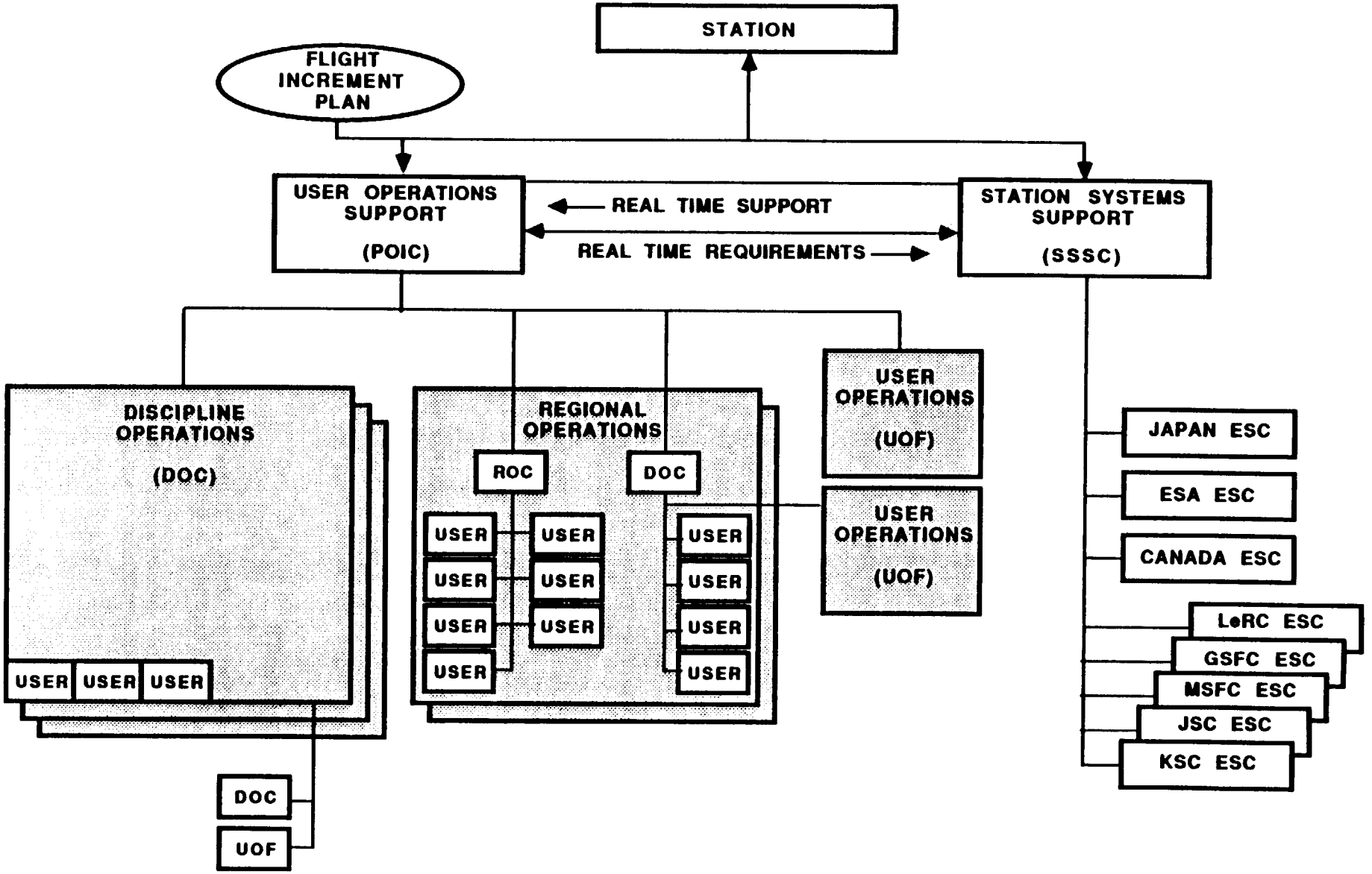


Figure 4-7

POIC ORGANIZATIONAL STRUCTURE

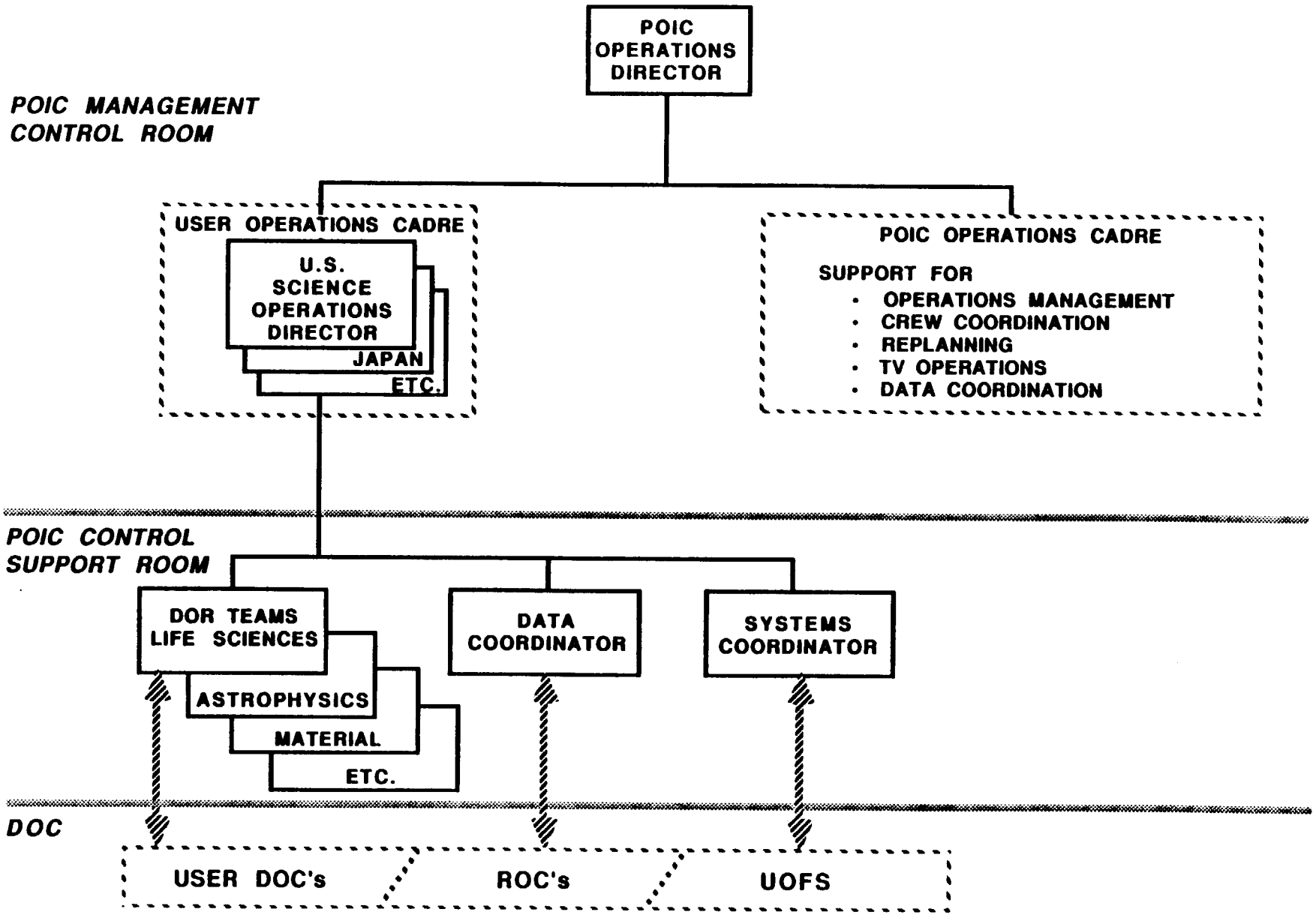


Figure 4-8

- Discipline Operation Center (SSOTF recommended) to support experiment and discipline training activities as well as operations coordination and management of PIs during real-time operations.
- UIF to support hardware integration activities, integrated science verification activities, integrated training for flight and ground personnel, and on-orbit replanning activities for OSSA payloads. (Hardware integration facilities require certification by the Space Station.)

S&T Centers require a high degree of fidelity in Station module and mode interfaces to support payload testing. These centers should be able to support:

- Pre-integration testing (form, fit, and function)
- Bench level and rack level integration testing
- Rack verification testing
- Science verification testing
- Data interchange between S&T and Station facilities (i.e., must be compatible with Space Station Ground Network).

OSSA Integration Facility should be a high fidelity complex consisting of U.S., JEM, ESA and node simulators and/or interface simulators to support:

- Experiment Compatibility Testing
- OSSA Integrated Payload Testing
- OSSA Payload Science Verification Testing
- Integrated Training / Simulations for flight crew
- On-orbit Support (flight-following)
- Simulated POIC for Ground Crew Training

Discipline Operations Center should support PIs and discipline/subdiscipline personnel during real-time operations. It is also recommended that OSSA DOCs be co-located with S&T centers for hardware integration and operations coordination.

Recommendations
Section 5.0

5.0 RECOMMENDATIONS

5.1 ADDITIONAL STUDY

Additional study effort is necessary to identify methods for implementing the recommended Integration Management Concept. Further study areas should include the following:

- OSSA Integration Facility Requirements Definition - identification of requirements and funding for facilities to support OSSA Payload Integration activities and real-time operations support.
- OSSA Science Payload Hardware / Experiment Certification and Verificaiton Requirements - define ground support requirements to certify and verify science payload hardware and investigations to be flown onboard Space Station.
- Mission Planning Tools/Methods Assessment for Space Station Applicability- identify applicable mission planning tools required to support Space Station flight increment design and development activities, on-orbit crew operations, and hardware utilization.
- OSSA Space Station Training Program Study - define OSSA Space Station Payload Training Program Structure and Plan for both flight and ground crews.
- OSSA Space Station Payload Operations Management Concept - define payload operations organization (similar to POCC) for OSSA payload users using baseline operations concepts.
- OSSA Integrated Logistics System Study - define and develop an Integrated Logistics System Plan for payload development.
- Space Station Vibration Study Plan - assess and evaluate the overall levels of vibration and the translation of vibration environments resulting from science payload hardware and equipment throughout the Space Station.
- Cost Model Development for integration of science payloads - develop a valid cost model using existing models and experience gained from previous programs to estimate costs of certifying OSSA facilities as S&T Centers.
- Generic Space Station Laboratory Equipment Definition Study for OSSA Payload Users - conduct technology assessments to define generic laboratory equipment and integration equipment that can be utilized by OSSA science payload users.

5.2 JSC ROLE / RESPONSIBILITY

The study team recommends that JSC assist OSSA in planning and implementing OSSA's integration activities for Space Station. JSC provides the full spectrum of engineering and technical services required to support OSSA payloads. Currently JSC provides quality mission management and project development for OSSA Spacelab and attached payloads and have been involved in OSSA Space Station planning activities. JSC experience on Skylab, Spacelab, and attached payloads on manned missions provides an effective experience base on which to draw for Space Station activities. Support provided to OSSA for pressurized modules and integration tools developed for past programs have direct application to pressurized modules on Space Station. Resources available at JSC to support OSSA integration activities are summarized in Figure 5-1. JSC Facility resources can become an OSSA institutional Space Station Integration Facility to provide effective and economical support of OSSA Payload Operations and integration activities (reference Figure 5-2) as a Space Station S&T Center and a Discipline Operations Center.

JSC RESOURCES AVAILABLE

Manpower

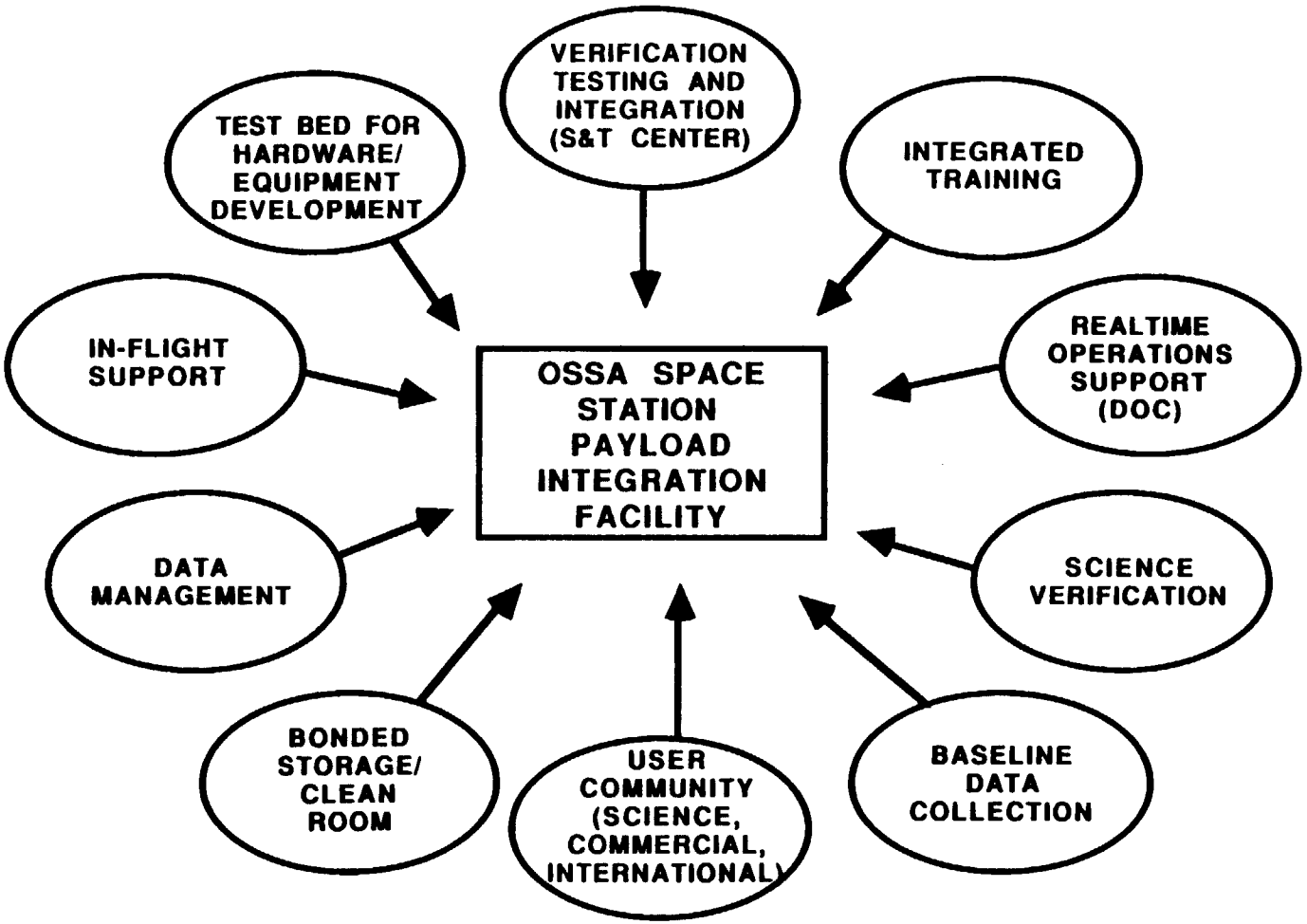
Civil Service	JSC
Contractor Support	RCA Government Services LEMSCO
Skill Mix	Management Crew Engineers Operations Specialist Data Specialist

Facilities Capability

Testbed for Hardware Development, Verification, Testing, and Integration	Baseline Data Collection
SR&QA Analysis	Science Verification
Integrated Training	Real-Time Operations Support
Space Station Crew Training	Bonded Storage / Clean Room
Space Station Mockup	Data Acquisition and Distribution
	Data Management

Figure 5-1

JOHNSON SPACE CENTER INSTITUTIONAL SUPPORT



JSC FACILITY RESOURCES CAN BECOME AN OSSA INSTITUTIONAL SPACE STATION INTEGRATION FACILITY TO PROVIDE EFFECTIVE AND ECONOMICAL SUPPORT OF OSSA PAYLOAD OPERATIONS AND INTEGRATION ACTIVITIES

Figure 5-2

Glossary / Definitions
Appendix A

GLOSSARY/DEFINITIONS

DISCIPLINE - a grouping of science and applications disciplines (i.e., Astrophysics, Life Sciences, Earth Sciences, Material Sciences and Solar System Research) that correspond to OSSA Divisions.

DISCIPLINE MANAGEMENT OFFICE - science discipline within the OSSA Headquarters code level office (i.e., Life Sciences, Material Science, Astrophysics etc.) that manages and coordinates discipline science activities.

DISCIPLINE OPERATIONS CENTER (DOC) - as currently defined by the SSOTF, user-supplied and operated facility which provides support to discipline user groups for interfacing with the Payload Operations Integration Center (POIC) for coordination of their payload planning activity during real-time operations.

DISCIPLINE OPERATIONS REPRESENTATIVE TEAMS - representatives from discipline organizations that support the Payload Operations Integration Center (POIC) during real-time operations. Teams should include science and engineering representatives to support payload replanning activities, data aquisition, and crew coordination.

FLIGHT INCREMENT - the interval of time between shuttle visits to the Space Station. Station operations are planned in units of flight increments.

FLIGHT INCREMENT PLANNING - flight increment planning is the last step in the planning process; the development of detailed resource schedules, activity templates, procedures and operations support data in advance of the final processing, launch and integration of payloads and transfer of crew.

GROUND OPERATIONS - this term includes all components of the Program which provide the planning, engineering, and operational management for the conduct of integrated logistics support, up to and including the interfaces with the users. Logistics, sustaining engineering, pre/post-flight processing, and transportation services operations are included here.

INTEGRATION - all the necessary functions and activities required to combine, verify, and certify all elements of a payload to ensure that it can be launched, implemented and returned to earth successfully.

MASTER INTERFACE FACILITY - facility provided by Space Station that will provide final interface checkout for user hardware to Space Station.

MATURE OPERATIONS - that period of time when all elements of the Space Station become fully operational and provide capability for crews to work comfortably and safely in the Space Station environment.

MULTILATERAL CONTROL BOARD - as defined by the SSOTF, consists of representatives from the Partner countries responsible for resource allocation and Station 5 year strategic planning activities.

MULTINATIONAL - all members of the USER community including the U.S. and international partners.

OSSA USER INTEGRATION FACILITY - a S&T center (described in the recommended OSSA Integration Management Concept), managed by OSSA UIO where experiment compatibility, science verification, hardware rack-to-module integration and integrated training activities are performed for OSSA science payloads prior to interface checkout at the launch site.

OSSA USER INTEGRATION OFFICE (UIO) - an OSSA sponsored organization responsible for management and analytical and physical integration of OSSA USER payloads.

PAYLOAD ACCOMMODATIONS MANAGER (PAM) - a Payload Accommodations Manager is assigned to each user selected under the Consolidated Utilization Plan (CUP) for participation in the SS Program. The PAM's primary responsibility is to serve as the user's advocate to the Program, and to facilitate the user's interactions with all operational aspects of the Program. The PAM will be assigned upon initial acceptance of the user and provide support through post-flight acquisition of all required data and hardware.

PAYLOAD INTEGRATION TRAINING FACILITY (PITF) - facility provided by the User community that will provide final user integrated training activities.

PAYLOAD OPERATIONS CONTROL CENTER (POCC) - user organization responsible for integrated user planning and real-time operations for Shuttle users. It is currently managed and controlled by the user community.

PAYLOAD OPERATIONS INTEGRATION CENTER (POIC) - a SS program-supplied organization and facility whose function is to manage user activities for the Space Station during real time operations. The POIC is responsible for integrating user requirements, developing the operations windows for each user, scheduling and managing the commands and data capabilities extended to them.

PAYLOAD TRAINING INTEGRATED FACILITY (PTIF) - facility provided by Space Station that will provide final SS integrated training activities.

PERMANENT MANNED CAPABILITY (PMC) - the period of time where a minimum of capabilities are provided, at the Space Station to allow crews of up to eight on various tour durations to comfortably and safely work in pressurized volumes indefinitely. Also includes provisions for safe haven and EVA.

REGIONAL OPERATIONS CENTERS (ROC) - as currently defined by the SSOTF, user (or partner) supplied and operated facilities which are geographically focused to provide support to regionally based user groups.

RESOURCE ALLOCATION - includes all the tasks for determining how the Station's available resources will be distributed among the USER community.

SCIENCE AND TECHNOLOGY (S&T) CENTERS - as currently proposed by the SSOTF, centers and facilities certified by Space Station and responsible for hardware integration and verification activities for user payloads.

SPACE STATION OPERATIONS TASK FORCE (SSOTF) - a study team created by the NASA Office of Space Station (OSS) to develop an operations framework for the Space Station era which meets the program objectives of safe and user-friendly operations, supports international participation in the operations of the Station and gives due consideration to the long term issues of the systems and user operations cost.

SPACE STATION PROCESSING FACILITY (SSPF) - the SSPF will house the prelaunch processing activity for all Space Station hardware to be transported to orbit (similar facilities will exist at other launch sites). In the Mature Operations Phases, the logistics flight hardware will undergo prelaunch and postlanding processing ("turnaround"). The SSPF will perform all interface and safety verification testing for the Program before delivering payloads and carriers to the transportation operations organization for STS or ELV integration.

SPACE STATION PROGRAM, SPACE STATION - these terms are used synonymously and should always be interpreted as global in nature, encompassing all of the component parts of the Program, manned and unmanned, both in space and on the ground.

SPACE STATION SCIENCE OPERATIONS MANAGEMENT CONCEPT (SSSOMC) STUDY - a study conducted jointly by the NASA Office of Space Science and Applications (OSSA) and the NASA Office of Space Station to provide options and recommendations for implementating their roles in managing U.S. Science users and payloads for Space Station.

TESTBED FACILITY - facilities located at subdiscipline centers where experiment hardware development, test and checkout activities are performed.

USER (United Space Experimental Researchers) - term given to all the varieties of potential users of the various Space Station elements. The term includes members of the U.S., NASA User organizations (Code E, R, C, M), Department of Defense (DoD), and international participants.

USER OPERATIONS FACILITIES (UOF) - as currently defined by the SSOTF, user-supplied and operated facilties to meet specific needs of the users.

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Appendix B

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